

## **Historic, Archive Document**

Do not assume content reflects current scientific knowledge, policies, or practices.



79 86 Miss  
Sppl 3

# SUPPLEMENTAL REPORT, MISSOURI RIVER BASIN AGRICULTURAL PROGRAM.

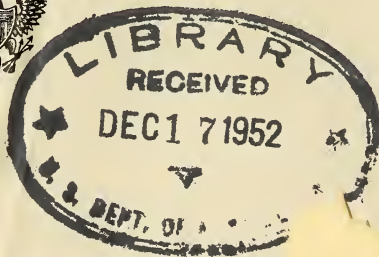
## LETTER

FROM THE

## SECRETARY OF AGRICULTURE

TRANSMITTING

THE FIRST "SUPPLEMENTAL REPORT, MISSOURI RIVER BASIN AGRICULTURAL PROGRAM"—THIS REPORT IS A SUPPLEMENT TO THE REPORT, "MISSOURI RIVER BASIN AGRICULTURAL PROGRAM," SUBMITTED SEPTEMBER 29, 1949, AND WHICH WAS PRINTED AS HOUSE DOCUMENT 373, 81st CONGRESS, 1st SESSION



JULY 4, 1952.—Referred to the Committee on Agriculture  
ordered to be printed, with illustrations

56  
UNITED STATES

GOVERNMENT PRINTING OFFICE

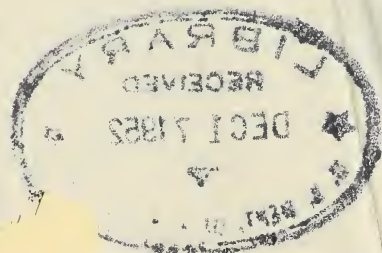
WASHINGTON : 1952

THE LIBRARY OF THE  
UNITED STATES OF AMERICA

THE LIBRARY

OF THE UNITED STATES OF AMERICA

THE LIBRARY OF THE  
UNITED STATES OF AMERICA  
DEPARTMENT OF THE ARMY  
WASHINGTON, D. C. 20315





## LETTER OF TRANSMITTAL

---

DEPARTMENT OF AGRICULTURE,  
OFFICE OF THE SECRETARY,  
*Washington, July 3, 1952.*

THE SPEAKER, HOUSE OF REPRESENTATIVES.

DEAR MR. SPEAKER: I am submitting herewith the first Supplemental Report, Missouri River Basin Agricultural Program. This report is a supplement to the report, Missouri River Basin Agricultural Program which I submitted to the Speaker of the House of Representatives on September 29, 1949, and which was printed as House Document 373, Eighty-first Congress, first session.

The enclosed report sets forth a broad program designed to abate flood and sediment damages, conserve and improve the soil for sustained productive use, protect and enhance the forest resource, provide for more efficient land use through irrigation and drainage, protect the water resource, and in other ways, including investigations, research, and surveys, to contribute to the full and efficient development, utilization, and conservation of specific watershed areas within the Missouri River Basin. One section of the report recommends a program of urgently needed soil surveys, land classification, and research for irrigation development for a large portion of the entire Missouri River Basin. Other sections recommend programs for the improvement of the watersheds of the Salt Wahoo Creeks, Nebr.; Blue River, Nebr. and Kans.; upper South Platte River, Colo.; Osage River, Mo. and Kans.; and Five Mile Creek, Wyo. The agricultural program for the Missouri River Basin was urgently needed at the time it was proposed in 1949. Subsequent events have emphasized that need, especially in the watersheds covered by this report.

I recommend that the Secretary of Agriculture be authorized to carry out the program proposed in the Supplemental Report, Missouri River Basin Agricultural Program.

The proposed report was sent to the Governors of all the concerned States and to the interested Federal agencies. Comments received to date are enclosed; others will be sent to you at a later date. Suggestions and comments will be utilized to obtain the fullest coordination practicable prior to the installation of the proposed plans of improvement.

The people living in the watersheds covered by the report are so intensely interested in this program that I am submitting the report to the Congress in advance of the end of the period normally allowed for review. The Bureau of the Budget advises that there would be no objection to this deviation from the usual procedure nor to the submission of this report to the Congress. A copy of the letter from the Bureau of the Budget is enclosed.

Sincerely,

CHARLES F. BRANNAN, *Secretary.*



## SUPPLEMENTAL REPORT, MISSOURI RIVER BASIN AGRICULTURAL PROGRAM

---

LETTER FROM THE BUREAU OF THE BUDGET TO THE SECRETARY  
OF AGRICULTURE

EXECUTIVE OFFICE OF THE PRESIDENT,  
BUREAU OF THE BUDGET,  
*Washington, D. C., June 2, 1952.*

The honorable the SECRETARY OF AGRICULTURE.

MY DEAR MR. SECRETARY: This will acknowledge receipt of your letter of April 16, 1952, requesting advice as to the relationship to the President's program of the proposals contained in your Department's report of March 1952, entitled "Missouri River Basin Agricultural Program Supplemental Report."

This supplemental report proposes that the first stages of installation of the program recommended in the Missouri River Basin agricultural program be undertaken in the watersheds of Salt-Wahoo Creeks, Nebr.; Blue River, Nebr. and Kans.; upper South Platte River, Colo.; and Osage River, Mo. and Kans. This program is based on estimates of total needed work that will be required to protect and enhance the agricultural productivity of the land and water resources and to make the maximum economical contribution to runoff and water-flow retardation and soil-erosion prevention. It proposes a program for the Five Mile Creek, Wyo., area designed to conserve and improve the soil and water resources for sustained productive use. It also proposes an acceleration of soil surveys and land classification in areas now irrigated or under investigation for new irrigation development in seven States of the basin.

Floodwater, sediment, and indirect damages occurring in these watersheds are estimated to average \$16,047,175 annually. The principal losses, estimated to average \$6,891,827 annually, are caused by flooding of agricultural crops. Gully and stream-bank erosion and flood-plain scour cause damages estimated at \$3,726,727 annually. Sediment damages are estimated at \$2,362,974, and flood damage to urban areas, roads, railroads, and bridges are estimated at \$2,937,347 annually.

It is proposed to alleviate these damages and to realize extensive associated benefits by installing a number of interrelated and interdependent soil and water conservation and control measures on the various watersheds during periods of from 10 to 20 years. Research, soil surveys, land classification, educational assistance, and technical services are also recommended parts of the proposed program.

Total costs and annual costs and benefits of the recommended program, by watersheds, are given in the following tables:

	Costs of recommended program		
	Federal	Non-Federal	Total
Land-treatment measures (accelerated program):			
I. Salt-Wahoo Creeks.....	\$10,781,230	\$8,406,650	\$19,187,880
II. Blue River.....	39,201,040	33,443,660	72,644,700
III. Upper South Platte River.....	39,098,600	13,953,900	53,052,500
IV. Osage River.....	62,063,100	51,168,600	113,231,700
V. Five Mile Creek.....	2,541,780	2,390,180	4,931,960
Subtotal.....	153,685,750	109,362,990	263,048,740
Small watercourse stabilization measures:			
I. Salt-Wahoo Creeks.....	6,207,000	1,615,700	7,822,700
II. Blue River.....	17,502,400	3,746,600	21,249,000
III. Upper South Platte River.....	8,652,200	1,240,600	9,892,800
IV. Osage River.....	55,542,800	17,673,200	73,216,000
Subtotal.....	87,904,400	24,276,100	112,180,500
Soil surveys, land classification, and irrigation research.....	8,185,000	3,279,000	11,464,000
Cost of recommended program.....	249,775,150	136,918,090	386,693,240

	Annual benefits and costs		
	Benefits	Costs	Ratio
Land-treatment measures:			
I. Salt-Wahoo Creeks.....	\$7,135,800	\$1,817,200	3.9 -1
II. Blue River.....	23,773,900	6,596,800	3.6 -1
III. Upper South Platte River.....	1,100,500	406,500	2.7 -1
IV. Osage River.....	36,452,220	10,833,317	3.4 -1
V. Five Mile Creek.....	773,900	472,880	1.6 -1
Subtotal.....	69,236,320	20,126,697	3.5 -1
Small watercourse stabilization measures:			
I. Salt-Wahoo Creeks.....	1,012,000	455,900	2.2 -1
II. Blue River.....	3,362,900	1,115,200	3.0 -1
III. Upper South Platte River.....	344,500	321,500	1.1 -1
IV. Osage River.....	6,489,680	4,497,000	1.4 -1
Subtotal.....	11,209,080	6,389,600	1.75-1
Total.....	80,445,400	26,516,297	3.0 -1

The Department believes it cannot fully and properly meet its responsibilities under the multiple-purpose and unified agricultural program envisioned in the report unless the full program is authorized and, therefore, authorization is sought for the entire agricultural program as contained in the report. Funds for structures and other measures primarily for flood prevention will be requested under the appropriation "Flood prevention." Funds for other phases of the program recommended in the report, upon approval by the Congress generally on the basis as submitted, will be sought as additions to going program appropriations of the agencies carrying on the work, citing as authority either the authorization by the Congress of the program recommended in the survey report or existing regular legislative authorities as the circumstances require.

The Bureau of the Budget is not in a position to advise you as to the relation of the report to the program of the President until we have had the opportunity of reviewing comments from the governors of the



concerned States and interested Federal agencies. There would be no objection to the submission of your proposed report to the Congress at this time, provided, however, that when reports from the interested States and Federal agencies are received, copies thereof will be furnished to the Congress and this Bureau.

In submitting your Department's report to the Congress, it will be appreciated if you include a copy of this letter.

Sincerely yours,

ELMER B. STAATS,  
*Assistant Director.*

---

LETTER FROM THE PUBLIC HEALTH SERVICE TO THE SECRETARY  
OF AGRICULTURE

UNITED STATES PUBLIC HEALTH SERVICE,  
FEDERAL SECURITY AGENCY,  
*Washington, May 20, 1952.*

HON. CHARLES F. BRANNAN,  
*Secretary of Agriculture, Department of Agriculture,*  
*Washington, D. C.*

DEAR MR. SECRETARY: Pursuant to the policies and procedures established by the Federal Interagency River Basin Committee, we have reviewed the United States Department of Agriculture's Supplemental Report on the Missouri River Basin Agricultural Program. Our comments on this report are enclosed.

We appreciate your giving us the opportunity to review this report.

Sincerely yours,

M. D. HOLLIS,  
*Chief Sanitary Engineering Officer, Public Health Service;*  
*FSA Member, Federal Interagency River Basin Committee.*

COMMENTS OF UNITED STATES PUBLIC HEALTH SERVICE, FEDERAL  
SECURITY AGENCY, REGARDING MISSOURI RIVER BASIN AGRICULTURAL  
PROGRAM SUPPLEMENTAL REPORT, TO UNITED STATES  
DEPARTMENT OF AGRICULTURE

The subject report is composed of a summary section and five sections covering individual subbasins under consideration. A sixth section is devoted to a proposed program of soil surveys and land classification. The following comments are presented on a basis of sections as used in the report.

SUMMARY SECTION

The report, prepared under authority of pertinent acts and resolutions, recommends an accelerated program for the watersheds of: (1) Salt-Wahoo Creeks, Nebr.; (2) Blue River, Nebr. and Kans.; (3) upper South Platte River, Colo.; (4) Osage River, Mo. and Kans.; and (5) Five Mile Creek, Wyo.; together with a program for soil surveys and land classification, at an estimated cost to the Federal Government of \$246,011,450 and an estimated cost to local interests of \$133,468,290 or its equivalent in labor, material, equipment, land, easements, right-of-way, and other contributions. Additional author-

ity would be supplemental to that now existing, and would include authorization to make modifications or substitutions of measures as set forth in the report as may be deemed advisable to further the objectives of the proposed program.

The accelerated program is a major portion of the total needed agricultural program in the area covered by the report. The total needed program is presented at an estimated cost to the Federal Government of \$339,684,310 and an estimated cost to local interests of \$574,195,360. The area covered by the report includes 36,122 square miles, or about 7 percent of the Missouri drainage basin.

Approximately 63 percent of the costs of the accelerated program would be borne directly by the Federal Government. Principal beneficiaries would be farm owners and operators through increased production and production efficiencies. Some benefits are claimed for communities in the form of reduced flood damage, decreased water-purification costs, and other incidental improvements. Benefits are claimed for the prevention of silt accumulation in flood control and power reservoirs. While monetary benefits other than to farm owners and operators are discussed, the total of these benefits are not readily apparent. However, they appear small in comparison to those projected for farm owners and operators.

It appears that the report does not demonstrate the ability of the recommended program to control floods resulting from (1) torrential rains of cloudburst proportions or (2) extended periods of rainfall where small structures would soon be filled and the ground would be fully saturated prior to termination of rainfall. No attempt is made to interpolate reductions in peak stream discharges in the Osage and Blue Rivers if the recommended program had been completed prior to 1951.

The report directs considerable discussion to benefits to flood control and other reservoirs due to reduced silt. Benefits cited appear insignificant as compared either to the cost of the recommended program or the cost of the reservoirs for which some measure of protection is provided, particularly in view of the silt allowance that already is included in completed reservoirs and which must be included in future reservoirs because of the long-term aspects of the recommended agricultural program. Since nonagricultural benefits represent a very small portion of the total benefits, and since the nonagricultural aspects do not influence the total cost of the program, it is suggested that nonagricultural benefits be so used and discussed as will not unnecessarily and unreasonably influence interpretation of the overall report.

The report recognizes silt as one of the numerous factors of pollution in the Missouri Basin and indicates some alleviation of this form of pollution. It does not, however, recognize animal wastes and refuse from feed lots and barnyards as an important source of organic pollution to the stream of the basin. It is entirely possible that much could be accomplished through the proposed program in preventing these wastes from entering our streams. It is hoped that the proposed program will be reviewed with respect to this important source of stream pollution.

## SECTION I. SALT-WAHOO CREEKS WATERSHED (NEBRASKA)

1. The closing sentence of the last paragraph of page I-8 states "The waters in streams that do have a fairly steady flow are not potable, even for livestock, because of high silt content and pollution." Our lower Platte report indicates that municipal and industrial wastes are discharged in the Salt-Wahoo Creeks watershed only in the vicinities of Lincoln, Ashland, Wahoo, and Weston. While additional treatment appears to be needed at Lincoln, and new plants are needed at Ashland, Wahoo, and Weston there is nothing to indicate that the effects of wastes discharged into these streams are as serious as stated in the subject report. We believe the statement to be incorrect with respect to industrial and municipal pollution, and quite misleading. It is our belief that in numerous areas of the Missouri Basin streams having higher silt content than Salt and Wahoo Creeks are successfully used as sources of stock water. Our lower Platte report indicates a chloride content in Salt Creek of 3,270 parts per million. Perhaps it is to natural chloride pollution that the report has reference.

2. Nonagricultural inundation damages in the basin are estimated at \$562,100 annually. The report does not indicate the extent to which these damages will be reduced by the proposed program or the reduction in peak stream discharges which may result from fulfillment of the program. It does not appear that sufficient data is given to permit evaluation of reduction in nonagricultural flood damages.

3. The third full paragraph of page I-15 states "Water supply and sewage disposal become major problems. There are additional after-costs of water treatment and pollution removal or dilution in smaller communities and rural areas." It appears that all communities in the subbasin use ground waters, with no resort to surface sources. Chlorides in Salt Creek appear to mitigate against its use as a source of water supply. The report does not indicate that minimum stream flows will be increased, by reason of the proposed program, so as to provide a benefit through permitting a lesser degree of sewage treatment at any community. It does not appear therefore that the proposed program will alleviate community problems of water supply and waste disposal. As the statement is misleading and probably irrelevant, we suggest its deletion together with any monetary evaluation of indirect damage which may have been attributed this item.

4. Page I-41 states that inundation damages will be reduced by 61 percent. Presumably this includes annual nonagricultural damages of \$562,100 as given on page I-13. If agricultural inundation damage (\$342,700) is wholly prevented, a reduction of almost 50 percent in nonagricultural damage must be brought about to provide benefits in inundation damage of \$507,300 as given on pages I-42 and I-43 (\$258,600 plus \$248,700). As it does not to us seem feasible that this reduction in damages can result from improved agricultural practices, we suggest that appropriate data and method of determining the reduction be included in the report.



## SECTION II. BLUE RIVER WATERSHED (NEBRASKA AND KANSAS)

1. The first paragraph of page II-14 states "Water-treatment costs for municipal water supplies are increasing because of suspended sediment. Two cities are adversely affected by the sediment load of streams." Table 1, page II-15, lists, under sediment damages, water-treatment costs in the amount of \$5,593 annually. While Washington, Maryville, Kans., and Nelson, Nebr., obtain water supply from surface sources, it is not conceivable that the proposed program would provide sufficient clarification of stream water by silt reduction so that normal coagulation and filtration of water supplies could be eliminated. Even with low turbidity, coagulation, filtration, and chlorination would be required for bacterial removal. It is thus questionable that any equipment, facility, or process could be eliminated in the water plants because of silt reduction resulting from the proposed program. Some reduction in chemicals used and in the cost of cleaning sedimentation basins appear possible, but \$5,593 annually seems an excessive estimate. Basic data and methods of calculation of this annual damage would be of interest to the Public Health Service. The proposed program might provide substantial benefit through lessening of silt accumulation in impoundments serving Washington and Nelson, thereby prolonging the useful life of these structures.

2. Table 1, page II-15, lists inundation damages as agricultural, \$4,732,027; nonagricultural, \$1,521,547; total, \$6,253,547. Page II-38 states inundation damages will be reduced by 39 percent. Page II-40 lists reduction in inundation damages through watercourse stabilization as \$1,117,300. Page II-39 lists reduction in land inundation and sediment damage through land-treatment measures as \$1,397,300. It does not appear possible to delineate from the report the estimated reduction in nonagricultural damage through inundation.

3. Pages II-39 and II-40 estimates annual reduction of sediment damages to proposed reservoirs as \$54,900 through land-treatment measures and \$5,500 through small watercourse stabilization. Total benefits from these measures are \$23,773,800 and \$3,362,900, respectively. Benefits to reservoirs resulting from the agricultural program are thus only a fraction of 1 percent of the total benefits of the proposed program, and appear insignificant as compared to (1) the cost of the agricultural program, (2) the cost of the reservoirs, or (3) the primary benefits of the agricultural program.

It appears that reservoir protection is a minor rather than a major justification for the agricultural program, and that the recommended program will offer but little real benefit to proposed reservoirs. The Department of Agriculture is to be commended on this factual presentation regarding which there has been considerable controversy.

## SECTION III. UPPER SOUTH PLATTE WATERSHED (COLORADO AND WYOMING)

1. The closing sentence of page III-6 states "The present facilities are inadequate to meet basic health and sanitation needs for either summer or winter recreational use." We wish to recommend that sanitary facilities for the 333 recreational and winter-sports facilities recommended on page III-27 be subjected to approval by the State



health authority before such work is begun or contracted for. This aspect of resource development does not receive mention in the subject report.

2. Page III-12 lists annual sediment damages as \$603,200. The closing sentence of page III-12 lists among sediment damages "the cost of increased water treatment due to excessive amounts of silt." Reference is made to our comment No. 11-1. It is not known what portion of the \$603,200 annual silt damage is allocated to community and industrial water supplies. Silt problems are minimal at most of the surface-water supplies in the upper South Platte Basin. It is suggested that data, information, and method of cost analysis regarding silt damage to water supplies be included in the report.

3. Page III-28 indicates 20 structures to control pollution from mine tailings. The cost of these structures is estimated on page III-42 as \$18,300 of which \$11,000 would be Federal funds. It is not indicated whether the mines in question are abandoned or active. While abatement of pollution from mine tailings is highly desirable, and in the case of abandoned mines is a complex problem, any approach to control of mine pollution should be a comprehensive one and should conform with the comprehensive program of the State health department for control of water pollution in the area. We question the possibility of materially alleviating pollution from mine tailings in the upper South Platte Basin through expenditure of \$18,300. We heartily endorse this activity provided the approach is a comprehensive one properly coordinated with the programs of official water pollution control agencies, State and Federal.

#### SECTION IV. OSAGE RIVER BASIN (KANS. AND MO.)

1. Table 1, page IV-14 includes, as sediment damage, water-treatment costs in the amount of \$39,400 for 17 communities using surface-water supplies. Six of these communities use impounded reservoirs, from which silt problems in the water-treatment plants would be expected to be minimal. Data in support of reduced cost of water treatment are not included in the report. These data would be of interest to the Public Health Service and we suggest that the report indicate the method of determining these benefits. No benefit is credited the proposed program for reduction of silting in the five municipally constructed impoundments for water supply, and the resultant increase in the useful life of these structures. It is possible that considerable benefits might accrue from protection of municipal water-supply impoundments.

2. Pages IV-39 and IV-40 list annual benefits to proposed reservoirs at \$50,100. See our comment No. 3 for section II.

3. Rather extensive strip-mining operations have been carried on in certain areas of the Osage Basin. Many of these strip mines have been abandoned. Considerable stream pollution in the form of acid mine wastes emanates from the abandoned mines. Fish life is known to have been destroyed in more than 100 miles of otherwise productive streams. It is believed that the land of these mine workings could be salvaged for certain agricultural purposes, which salvage would, as a secondary benefit, tend to reduce or eliminate stream pollution of considerable concern to the Missouri Conservation Commission. It is recommended that strip-mine workings receive appropriate

consideration in the proposed program, if such action has not already been taken.

#### SECTION V. FIVE MILE CREEK (WYO.)

1. On page 11, section V, mention is made of wells, water-storage tanks, and pipelines for water supplies for domestic and other purposes. Use of surface water for individual domestic systems is associated with significant public-health hazards. For this reason it is recommended that rules and regulations of the State health authority be adhered to in the development of domestic supplies. Plans and specifications for such work should be approved by the State health authority before the work is begun or contracted for.

#### SECTION VI. IRRIGATION DEVELOPMENT, SOIL SURVEYS AND LAND CLASSIFICATION

No comment.

#### VECTOR CONTROL

Since the programs recommended by the Department of Agriculture for the two western watersheds involve chiefly conservation irrigation measures, the prosecution of such programs will tend to minimize mosquito production and thus will be beneficial from the public health standpoint.

We would like to see inserted in the report under the topic "Flood damages," (indirect damage), a statement to the effect that prodigious numbers of floodwater mosquitoes are produced as a result of floods. This pertains especially to sections I, II, and IV. Many people are not cognizant of the fact that the most common and the most formidable pests of man and livestock in the Missouri Basin are floodwater mosquitoes (*Aedes vexans*). The report stresses that the recommended programs will assure "conservation of land and water resources." We would like to add, "and human resources."

In several sections reference is made to the construction of various types of farm ponds. It is envisioned that these will be constructed in such a manner that they will not be major producers of mosquitoes. In section IV (the Osage River watershed, Kansas and Missouri) it is stated that: "An estimated 34,300 livestock water ponds need to be developed to provide adequate watering facilities." It is of interest to note that Missouri presently has more than 100,000 conservation stock ponds, and these ponds have not presented major problems in mosquito control.

In section V it is stressed that a critical situation with reference to seepage exists at the Five-Mile Creek watershed in Wyoming. This area is notorious for the inefficiency in the use of irrigation water and land. This suggests that it is probably also notorious from the mosquito standpoint. In view of the vast increase in irrigated pastures as recommended by the Department of Agriculture, health agencies are concerned with the probable increased potential in mosquito breeding. Irrigated pastures are the No. 1 mosquito problem in most irrigated areas. Therefore, whenever irrigated pastures are developed in the Five-Mile Creek watershed, extra precautions should be taken to see that provision is made for proper land leveling and for drainage.

LETTER FROM THE GOVERNOR OF KANSAS TO THE SECRETARY  
OF AGRICULTURESTATE OF KANSAS,  
OFFICE OF THE GOVERNOR,  
*Topeka, June 12, 1952.*Hon. K. T. HUTCHINSON,  
*Assistant Secretary, Department of Agriculture,*  
*Washington, D. C.*

MY DEAR SIR: Reference is made to your letter of April 10, 1952, transmitting a copy and requesting my views on the United States Department of Agriculture's supplemental report on the Missouri River Basin agricultural program.

I am particularly interested in sections II and IV of your report which deal with the Blue and Osage River watersheds, respectively. Each includes important areas within the State of Kansas which are confronted with serious problems of flood control, water supply, soil-erosion prevention, and runoff and water-flow retardation.

We have urged many times in the past that the Department of Agriculture features of the Missouri Basin development program be advanced to the construction and installation stage and feel that action in this matter has been long delayed. People in the Kansas portion of the basin have organized soil-conservation districts in all except two counties and are prepared to cooperate in putting the program into effect.

The programs for the Blue and Osage River watersheds, as set forth in your report, I am sure are highly desirable. I extend herewith my approval of your report and endorse the program which is recommended therein. It is urged further that the report be transmitted to Congress at the earliest opportunity; that the proposed work be authorized; and that appropriations be made to put the program under way.

Yours very truly,

EDWARD F. ARN, *Governor.*

LETTER FROM THE FEDERAL POWER COMMISSION TO THE  
SECRETARY OF AGRICULTUREFEDERAL POWER COMMISSION,  
*Washington 25, June 13, 1952.*

Subject: Missouri River Basin agricultural program, supplemental report.

Hon. CHARLES F. BRANNAN,  
*Secretary of Agriculture, Washington 25, D. C.*

DEAR MR. SECRETARY: The comments herein relative to your Department's supplemental report, dated March 1952, on the agricultural program for the Missouri River Basin presented in House Document No. 373, Eighty-first Congress, first session, are in response to Assistant Secretary K. T. Hutchinson's letter of April 10, 1952. The transmittal of these comments is in accordance with established procedures of the Federal Inter-Agency River Basin Committee.



The supplemental report proposes that the first stages of installation of the program for the conservation, development, and use of land, water, and forest resources set forth in House Document No. 373 be undertaken in the watersheds of Salt-Wahoo Creeks, Nebr.; Blue River, Nebr. and Kans.; upper South Platte River, Colo.; and Osage River, Mo. and Kans. The supplemental report also proposes a program designed to conserve and improve the soil and water resources of the Five Mile Creek watershed, Wyoming, for sustained productive use. Furthermore, the supplemental report proposes that soil surveys and land classification be carried on at an accelerated rate in areas now irrigated or being investigated for new irrigation development in seven States in the Missouri Basin.

The work proposed and recommended in the supplemental report includes measures for the improvement of cropland, grasslands, and forests, and measures for stabilizing small watercourses. The installation of these recommended measures and practices would constitute an acceleration of the Department of Agriculture's "going programs" for similar activities in these watersheds. The report recommends that this proposed work be completed in the Blue River, Upper South Platte, and Osage River watersheds in 20 years, and that the programs proposed for the Salt-Wahoo Creeks and Five Mile Creek watersheds and the soil surveys and land classification of 7,285,000 acres be completed within 10 years.

The total cost of the recommended accelerated program, including the cost of the "going program," is estimated to be \$574,195,360, of which \$339,684,310 would be borne by the Federal Government, \$14,410,400 by non-Federal public groups, and \$220,100,050 by private interests. Estimates of costs and benefits shown in the report indicate that the proposed measures are economically justified.

The Commission staff has reviewed your Department's supplemental report on the Missouri Basin agricultural program and advises that the development of hydroelectric power is not feasible in connection with the recommended improvements. Although a substantial number of floodwater detention dams are proposed for the temporary impoundment of the excess runoff from small drainage areas, these structures and the attendant conditions of small flows and low heads would not be suitable for use in connection with power development.

The over-all effects of the programs for water-flow retardation and soil-erosion prevention recommended in the supplemental report might be expected to be generally favorable to the production of hydroelectric power downstream from the areas to be improved as the runoff from snowmelt and rainfall would be regulated to some extent and reservoir life would be prolonged by reduction of sediment in tributary streams.

The Commission appreciates the opportunity of reviewing and commenting upon the report of your department.

Sincerely yours,

THOMAS C. BUCHANAN,  
*Chairman.*

LETTER FROM THE GOVERNOR OF MISSOURI TO THE SECRETARY  
OF AGRICULTUREEXECUTIVE OFFICE,  
STATE OF MISSOURI,  
*Jefferson City, July 8, 1952.*Hon. CHARLES F. BRANNAN,  
*Secretary of Agriculture, Washington, D. C.*

DEAR MR. SECRETARY: In response to your letter of April 10, 1952, requesting comments and views on the supplemental report of the "Missouri River Basin agricultural program," I am pleased to comply herewith.

I find the program you are proposing for the Osage River Basin is in general agreement with the State's attitude toward a comprehensive program for the development of its land and water resources. It is also noted that the principles embodied in your program are generally the same as those worked out in the cooperative study on the Osage Basin. We have long recognized that a program for upland management, including forestry and agriculture, is a prerequisite of comprehensive resource planning.

Your report for the Osage River Basin recommends an accelerated program to be installed over a 20-year period. A good share of the cost is by local participation and this is certainly desirable. Because such a large share of the program must be carried out by individual farmers it is essential that an adequate educational program be initiated early in order to assure success of the entire program. Likewise, an adequate research program is essential to the success of the recommended program. The College of Agriculture and our Forestry Division have such programs now under way in the State and will be ready to render any service or guidance necessary to insure proper continuance of these programs. It is our firm belief that research and educational work should proceed prior to the establishment of a going agricultural program in order to assure the maximum cooperation of the individual farmer.

Detailed analysis of the individual measures, as well as their economics, proposed for forestry and agriculture have not been made at this time. Similarly, we have not analyzed in detail the measures proposed for stabilizing small water courses. We recognize that the need for these measures in the basin is clearly evident and that final details can be worked out prior to their installation.

It is our understanding that the program you are presenting is necessarily very general and that final planning will be worked out in detail and in consultation between your department and our interested State agencies as well as the people in the area. I wish to assure you that the State stands ready to give full cooperation in working out such details. I feel certain that such a program must have the full cooperation of all concerned if it is to achieve any measure of success.

Very truly yours,

FORREST SMITH, *Governor.*

LETTER FROM THE CHIEF OF ENGINEERS TO THE SECRETARY  
OF AGRICULTURE

DEPARTMENT OF THE ARMY,  
OFFICE OF THE CHIEF OF ENGINEERS,  
*Washington 25, D. C., July 31, 1952.*

The honorable the SECRETARY OF AGRICULTURE.

DEAR MR. SECRETARY: Reference is made to the supplemental report of the Department of Agriculture on the Missouri River Basin agricultural program which has been furnished to the Corps of Engineers for comment.

The report is supplemental to your report "Missouri River Basin agricultural program" which you submitted to the Speaker of the House of Representatives on September 29, 1949 (H. Doc. 373, 81st Cong., 1st sess.). Your supplemental report proposes that the first stages of installation of the recommended Missouri Basin agricultural program be undertaken in the watersheds of Salt-Wahoe Creeks, Nebr.; Blue River, Nebr. and Kans.; Osage River, Mo. and Kans.; and upper South Platte River, Colo.

The report states these programs are designed to protect and enhance the agricultural productivity of land and water resources and to make the maximum economical contribution to runoff and water-flow retardation and soil-erosion prevention. The report also proposes a program for Five Mile Creek, Wyo., designed to conserve and improve the soil and water resources for sustained productive use. This program recommends an acceleration of soil surveys and land classification in areas now irrigated, or under investigation for new irrigation development, in seven states of the Missouri Basin. The report recognizes that considerable work along these general lines is now being accomplished under existing programs of the Department of Agriculture, and presents estimates totaling \$574,195,360 as the cost of the total needed programs in the five watersheds and for the program of soil surveys and land classification. The estimated cost of the recommended accelerated programs, over and above the going programs, necessary to complete the work within time periods ranging from 10 to 20 years is \$379,479,740, of which the Federal Government would expend \$246,011,450.

Aside from the program of soil surveys and land classification, upon which no comment appears appropriate, the program breaks down into two major classes of improvements. The first of these, comprising about 70 percent of the total cost of the recommended accelerated program and an even greater proportion of the estimated benefits, is classed as land treatment measures, and includes terraces, erosion control structures, crop rotations, seeding pastures and ranges, outlets and waterways, shelter belts, forest protection, planting and improvement, together with associated technical service, research, direct aids, and education. The entire program proposed for Five Mile Creek appears to be in this general category and is designed principally to improve efficiency in the use of irrigation water and land. Since this part of your program is predominantly agricultural in nature it does not appear appropriate for me to comment in detail on this phase. It appears, however, that measures of this kind would be of great value to the land upon which they are installed; although it is



believed that more information is needed as to the long-range effect of such measures on low-water flows of streams.

In connection with land-treatment measures I am pleased to note that your report deals plainly with a point which in the past apparently has not been fully understood by some; namely, that the intensity of many rains will exceed infiltration capacities of the soils, and that runoff of flood-forming proportions will occur even under the most favorable conditions of land use and treatment. However, I note that, while the benefits ascribed to this work for reduction of flood-water and sediment damage are only a very small fraction of the estimated conservation benefits, they are, in most cases, more than 50 percent of the benefits you expect to accrue from reduction of flood-water and sediment by the entire program, including numerous floodwater retarding reservoirs. It may be that in your terminology, "flood damage" includes damage on the uplands occasioned by overland runoff on its way to defined watercourses and channels. Otherwise such values appear high. In any event, I agree with the statement in your report that there is an increasing need for a better understanding of the effects of land use and conservation measures upon the rate and amount of runoff from watersheds.

The second class of improvements in your recommended program for Salt-Wahoo Creeks, Blue River, upper South Platte River, and Osage River involve stabilizing measures for small watercourses, including floodwater retarding dams, sediment-control structures, diversion dikes, floodways, and channel improvements; approval of which is recommended under the Flood Control Acts. I am particularly concerned with this phase of the program because it is closely interrelated with flood-control works and problems which are the responsibility of the Corps of Engineers.

I feel that more data are needed before detailed comments can be made on the second class of improvements recommended in your report, and certainly before you seek authorization for their construction. As you know, joint studies, with a view to developing a coordinated plan for the Salt-Wahoo Basin, have been carried on for some months by the field offices of our two agencies. On the basis of these joint studies to date, we do not feel that the program you propose for this basin provides a degree of flood protection that is adequate and sound from engineering and economic standpoints. Apparently the desire of your department to submit this separate report has temporarily deferred completion of the joint studies which we consider necessary and desire to continue. My further comments on the part of your program intimately related to flood-control operations under the jurisdiction of the Corps of Engineers are reserved, therefore, until completion of the coordinated study.

Sincerely yours,

LEWIS A. PICK,  
*Lieutenant General,  
Chief of Engineers.*

LETTER FROM THE ACTING SECRETARY OF AGRICULTURE TO  
THE CHIEF OF ENGINEERS

SEPTEMBER 18, 1952.

Lt. Gen. LEWIS A. PICK,  
*Chief of Engineers, Department of the Army.*

DEAR GENERAL PICK: Your letter of July 31, 1952, comments on the Department of Agriculture's supplementary report to the Missouri River Basin agricultural program. We feel that your comments require a brief explanation.

In developing our proposed program for the Salt-Wahoo Creeks watershed we anticipated that the Corps of Engineers would also develop a plan of flood control so that the combined plans would provide adequate flood protection for the basin. Consequently we did not attempt to prepare a plan for complete flood protection. We believe that our recommended program is sound for the purpose intended from an engineering and economic viewpoint. This is based on the costs and the benefits claimed, but the justification for the program is contained in appendix and file material not presented in the report. The same comment applies to the programs recommended for the other watersheds covered in the report.

The Department of Agriculture shares your desire to continue joint studies with a view to developing a coordinated plan in the best interests of the people of the Salt-Wahoo basin. We feel, however, that such studies can be accomplished most successfully during the work planning stage of program development. At this stage, prior to beginning construction of any of the improvements or structures involved, the program of this Department will be coordinated to the fullest extent practicable with the plan under development by the Corps of Engineers.

We hope that this explanation and the further offer of cooperation will provide a basis for your more complete endorsement of our proposed program.

Sincerely,

C. J. McCORMICK, *Secretary.*

LETTER FROM THE GOVERNOR OF ILLINOIS TO THE ASSISTANT  
SECRETARY OF AGRICULTURE

STATE OF NEBRASKA,  
EXECUTIVE OFFICE,  
*Lincoln, August 15, 1952.*

Mr. K. T. HUTCHINSON,  
*Assistant Secretary, Department of Agriculture,*  
*Washington, D. C.*

DEAR MR. HUTCHINSON: I have studied the Department of Agriculture's supplemental report—Missouri River Basin agricultural program—and although the proposed program is largely experimental, in my opinion, it is fundamentally sound. If the proposals are carried out, the land and water resources of the watersheds should be greatly improved and conserved while the annual damages from floods in the area are being reduced substantially. Therefore, I am happy to advise



you that I plan to give my full support to the program outlined in the supplemental report.

Sincerely,

VAL PETERSON, *Governor.*

---

LETTER FROM THE GOVERNOR OF WYOMING TO THE ASSISTANT  
SECRETARY OF AGRICULTURE

WYOMING,  
EXECUTIVE DEPARTMENT,  
*Cheyenne, August 25, 1952.*

MR. K. T. HUTCHINSON,  
*Assistant Secretary of Agriculture,*  
*Washington, D. C.*

DEAR MR. HUTCHINSON: Agreeable to the request contained in your letter of April 10, 1952, I offer the following comments on your Missouri River Basin agricultural program, supplemental report.

I do not feel qualified to comment on the program other than the portion that pertains to the State of Wyoming, and therefore what is written here pertains only to that State.

Wyoming is particularly interested in the proposal in the report on the Five Mile watershed in Fremont County. We feel that the situation here is serious and while the cost estimate appears to be rather high, that your agency and the Bureau of Reclamation can solve it in the best interest of all concerned. In conclusion, I will say that the portion of your program pertaining to the State of Wyoming has the approval of our State.

Very truly yours,

FRANK A. BARRETT, *Governor.*

---

LETTER FROM THE ACTING SECRETARY OF THE INTERIOR TO  
THE SECRETARY OF AGRICULTURE

DEPARTMENT OF THE INTERIOR,  
OFFICE OF THE SECRETARY,  
*Washington 25, D. C., August 27, 1952.*

HON. CHARLES F. BRANNAN,  
*Secretary of Agriculture, Washington, D. C.*

MY DEAR MR. SECRETARY: These are the comments of the Department of the Interior on the supplemental report by the Department of Agriculture on the Missouri River Basin agricultural program. Copies of the report were transmitted for review with your letter of April 10.

The report recommends that the Secretary of Agriculture be authorized to carry out accelerated program for improvement of agricultural resources in five watersheds in the Missouri River Basin and to carry out soil surveys and land classification of irrigable lands throughout that basin. The cost of the accelerated program is estimated to be somewhat more than \$379,000,000. The Federal Government's share of this cost would be \$246,000,000. Other public interests and private interests will bear the remaining cost. Although no

single cost benefit ratio is given for the total recommended program, that in each of the watersheds is shown to be greater than unity.

#### GENERAL COMMENTS

The recommended programs run the full gamut of measures for land treatment and for stabilizing small watercourses. The Department of the Interior concurs in the need for improvement and preservation of the land resources of the Missouri River Basin. We do not feel, however, that the report presents adequate data to support the authorization of so comprehensive a program. Little or no basis is presented for any of the quantities or estimates forming the substance of the program and its appraisal. It has therefore not been possible for the agencies of this Department to appraise the validity of these figures.

For example, the justification for and the description of a program for erosion control structures in the Blue River Watershed, which will cost the Federal Government more than \$3,000,000, are contained in a little more than three lines of text. A similar stereotyped and curt description is used to justify erosion control structures for each of the other four watersheds involving an aggregate Federal expenditure of about \$3¼ million. In no case is any basis given for the selection of the number of structures indicated. Evidence is not presented as to where the watershed structures will be built, nor is there any attempt to describe, even in a general way, the physical characteristics of these structures.

This treatment of erosion-control structures is typical of the treatment of all elements of the program. The same result could be accomplished just as effectively simply by presenting a series of cost tables. Thus, the report proposes to provide the Secretary of Agriculture with a blank check for a program involving a Federal expenditure of a quarter billion dollars. As indicated, we endorse the objectives of these programs but, with the information given in the report, we are unable to judge whether the measures proposed would accomplish these objectives.

The material in the report on program appraisal is handled in a manner similar to that of the description of the program elements. The benefits for many of the elements are lumped, and there is no description as to how they were computed. A program of this magnitude should, in our opinion, be presented on a firmer basis.

#### *Inadequate coordination with Interior agencies*

In our opinion there has been inadequate recognition of the interests of the Department of the Interior in the preparation of the report. In some of the five watersheds there is a considerable acreage of public land under the jurisdiction of the Bureau of Land Management of this Department. There is no way of ascertaining in the report what is proposed for these lands in the way of erosion control and runoff reduction measures. There is no provision for funds to be used by that Bureau in participating in the further surveys nor for carrying out the watershed improvement plans recommended.

The same lack of coordination is the case with respect to the programs of the Geological Survey. The letter to you from this Department of August 4, 1949, commenting on Agriculture's previous

Missouri Basin report, pointed out the assistance which could be provided by the Geological Survey in the development of basic topographic, hydrologic, and geologic data needed for successful prosecution of the agricultural program in that basin. Your response of September 9, 1949, gave assurances that the Department of Agriculture would make full use of the cooperation offered by the Geological Survey. Yet there is little evidence that the facilities of the Survey have been utilized in the preparation of the current report. There is no reference to the Survey as a source of basic data or as an actual or potential collaborator in the collection and use of water resources data, the appraisal of stream-flow records, analysis of the need for additional data, and other information which is fundamental to a program of the type proposed by the Department of Agriculture.

Similarly, the probable effects of the program on fish and wildlife resources are largely ignored even though brief attention is given to improvement of wildlife habitat in several sections of the report. Many of the other measures, of course, particularly drainage and pasture clearing, will have a substantial effect on fish and wildlife resources. The report implies that all of the measures recommended will be beneficial to these resources, but it is clear that some of the program elements, particularly the two mentioned above, will have exactly the opposite effect. The Fish and Wildlife Service of this Department has prepared and supplied to you a report dated November 1948 entitled "A Preliminary Evaluation of the Effects of the Proposed United States Department of Agriculture Flood Control Program on Fish and Wildlife Resources in Missouri Basin." Your supplemental report shows little indication that the policy recommendations in the Fish and Wildlife report have been given consideration.

The report fails to note relationship of the recommended program to mineral interests in the Missouri River Basin. The Bureau of Mines of this Department has the data necessary to permit your Department to deal adequately with this situation.

#### *No evaluation of effect on water resources*

The report contains no evaluation of the effect of the recommended program on water resources. Measures like drainage, construction of flood water retarding structures, channel improvements, and construction of sediment-control structures will have a profound effect on both surface and groundwater supplies. Ignoring of these effects in your report is a serious deficiency, particularly in these areas which are subject to aridity and drought.

Terms like "reduction of runoff" and "conservation of moisture" are used frequently in the report in connection with programs for the planting of legumes and grasses and development of shelter belts. The effect of these measures on water supplies and regulation is too little known and uncertain to utilize as a basis for justification.

An important phase of the recommended program is the construction of ponds for stock water and irrigation supplies. These impoundments are likely to have a significant effect on runoff, especially because of the increased evaporation and resultant loss of water. Yet no recognition of this fact is included in the report. In this connection the question of water rights involved in the consumptive water use which will stem from these measures should



appropriately be dealt with in the report. No discussion of this problem is presently included.

*Range users should bear O. and M. costs*

Under the heading "Local participation and cooperation" it is stated that the treatment measures on Federal lands incorporated in the program will be installed, operated, and maintained at Federal cost. This is contrary to policies of this Department with respect to administration of Federal grazing lands under which the cost of operation and maintenance is to be borne by range users.

*Effect on fish and wildlife*

There is need for detailed consideration of fish and wildlife resources in connection with the administration of the proposed programs in the five watersheds. The lack of specific plans in the report prevents us from contributing the detailed recommendations as to how provisions should be made for protection of these resources at this time. If the program recommended is authorized, the Fish and Wildlife Service stands ready to participate appropriately in this phase of the work.

The drainage phases of the program will, as earlier implied, have a particularly profound effect on fish and wildlife resources. The supplemental report does not specifically mention collaboration with the Fish and Wildlife Service in the survey and approval of drainage projects. Nevertheless we are relying on your letter of September 9, 1949, to this Department, which states that drainage projects in Agriculture's program for the Missouri River Basin will be carried out only in areas delineated in cooperation with wildlife conservation agencies and that such work will be subject to agreement with the Fish and Wildlife Service.

SALT-WAHOO CREEKS WATERSHED

There is no mention in the report of the need for new topographic maps as a basis for additional planning of the program measures in the Salt-Wahoo Creeks watershed. What topographic maps are available for this watershed are of reconnaissance type and were prepared many years ago. No current topographic mapping projects are under way. We feel that this situation should have recognition in the report and that there should be a recommendation for additional topographic mapping.

The report discusses the development of irrigation by ground water pumping for a minimum of 25,000 acres in the watershed. It is stated that ground water supplies are adequate to supply 6 to 12 inches of water per acre for this area. No evidence, however, is presented to support this estimate.

Under the heading "Reduction of Water Runoff and Sedimentation Production" there is proposed a study of rainfall-runoff relationships. Such a study should include the effect of land use changes on ground water, including the effects on the water table and on ground water recharge and discharge. The Geological Survey is the logical agency to make studies of this character.

The Survey now operates four gaging stations in the Salt Creek Basin. These will assist in the detailed study of runoff accumulations which will be required. Stream flow records of a high order of accuracy are required to meet the objectives of the study pro-

grams proposed by the Department of Agriculture. It would be appropriate for the Department of Agriculture to request the participation of the Geological Survey in carrying out those studies. This applies not only to the Salt-Wahoo Creeks watershed, but also to all of the other watersheds covered by the supplemental report.

In the section on program appraisal it is estimated that land damages from floods will be reduced by 82 percent as a result of the program proposed by the Department of Agriculture. Reduction in inundation damages is claimed to be 61 percent and reduction in sediment damages, 80 percent. No basis for these estimates is given; they seem to be extremely high.

#### BLUE RIVER WATERSHED

As in the Salt-Wahoo Creeks watershed, the Blue River watershed is covered inadequately by topographic maps. There is an item in the program for the Blue River watershed of \$505,000 Federal cost for soil surveys and land classification. Up-to-date topographic maps appear to be essential, and we recommend that the program contain recognition of this need.

The report discusses the irrigation, by ground-water pumping, of approximately 420,000 acres in the Blue River watershed and recommends approval of an initial program for the irrigation of 50,000 acres. These proposals are based on the "calculated average annual ground-water supply." No figures are given as to the amount of irrigation water to be supplied. If it is proposed to supply for the 420,000 acres 6 to 12 inches of water per acre per year, as in the adjoining Salt-Wahoo Creeks Watershed, 210,000 to 420,000 acre-feet of ground water would be required for this purpose in the Blue River Basin. The water-bearing formations underlying the bulk of the Blue River Basin are not capable of yielding this quantity of water. Productive water-bearing deposits exist only in the alluvium of the major stream valleys. Thorough ground-water studies are required to support an estimate of irrigation development anything like that proposed in the report; none apparently was made prior to the submission of the report.

#### UPPER SOUTH PLATTE WATERSHED

The program recommended for the upper South Platte watershed includes the rehabilitation of irrigation ditches, the building of small irrigation structures, and the lining of ditches in areas presently irrigated. On projects of the Bureau of Reclamation of this Department, some of which are in the same area, costs of such work are borne fully by water users. These rehabilitation and betterment activities by the Bureau of Reclamation are undertaken only after completion of careful investigation and the preparation of detailed plans, all in the interest of maximizing the operating performance of the project irrigation works and with full consideration of the ability of the water users to bear the costs. Thus the demonstrated physical need for rehabilitation and betterment is in every case related to economic factors affecting the financing of the work by Federal and local interests.

By contrast, your report makes provision only for sharing of the cost as between the water users and the Federal Government in



order to insure establishment of the recommended program. Nearly 30 percent of the costs are proposed to be paid by the Federal Government. No justification for this Federal expenditure is presented nor is there any evidence presented as to the ability of the water users to bear the remainder of the cost. It is obviously wrong for one Federal agency to require full repayment of rehabilitation and betterment costs on irrigation developments, while another Federal agency undertakes the same type of activity in the same area and provides at Federal expense nearly one-third of the needed work. We recommend that the Department of Agriculture carry out this rehabilitation and betterment only under policies similar to those followed by the Bureau of Reclamation, which require full repayment for the rehabilitation and betterment work done by the Federal Government.

It is proposed in the section of the report on the upper South Platte watershed that the Bureau of Reclamation will provide land for experiments on one or more development farms in the Colorado-Big Thompson project. Moreover, it is implied that the research and demonstration undertaken on such farm or farms would be carried out by the Department of Agriculture and the Colorado Agricultural Experiment Station. In farms of this type established on other Federal irrigation projects, the Bureau of Reclamation has been an active participant in the demonstration phases. We would expect this to be the case on the Colorado-Big Thompson project. However, all of the lands in the Colorado-Big Thompson project are privately owned; it is therefore not clear how the Bureau of Reclamation would be expected to provide land for development-farm use.

In the South Park area of this watershed, the Bureau of Land Management has in progress a conservation program on public-domain lands in cooperation with range users. It is proposed to accelerate this program, which consists mostly of range revegetation, considerably during the next few years. There is no evidence in your report that this program has been given adequate consideration or included in the proposals of the Department of Agriculture. Instead, there is a marked contrast between the detailed discussion given to the problems and programs for the national forests as opposed to the scant reference to the lands in the public domain. All told there are nearly 600,000 acres of lands in the watershed under the jurisdiction of the Bureau of Land Management and the National Park Service. A land-conservation program which does not take appropriate account of the problems on so substantial a proportion of the area of the watershed is not adequate.

Somewhat more than one-half of the upper South Platte River watershed is covered by topographic maps considered adequate for most purposes. Most of these maps were made from surveys completed by the Geological Survey in the last 10 to 15 years. This apparently has been overlooked by the Department of Agriculture in view of the statements in the report on the need for new land surveys and maps. The report proposed the expenditure of about \$940,000 for the surveying and mapping of 8,940 square miles in the watershed. This is some 98 percent of the total basin area. On the basis of the stated needs the published quadrangles of the Geological Survey should be adequate for most needs. Moreover, copies of the original manuscript of the maps at larger scales are available for most of the areas mapped. We recommend that the Department of Agriculture

make use of these maps instead of spending additional Federal funds for duplicate work.

#### OSAGE RIVER WATERSHED

Program for the Osage River watershed incorporated in the report includes research on reduction of runoff and sedimentation. It is our view that these studies should also include investigation of ground water resources, because of their importance to the economy of the area. The Geological Survey will be pleased to participate in such investigations.

In connection with the effect of the recommended program for the Osage River watershed on fish and wildlife resources, your attention is invited to the study made by the Missouri Conservation Commission in 1947 during the cooperative survey of the Osage River Basin.

No mention is made in the report of coal mining operations in the Osage River watershed. Most of these operations are of the strip-pit type. Rehabilitation studies of the exhausted pits might well be a fruitful source of measures for land improvement in the basin.

#### FIVE MILE CREEK WATERSHED

The program recommended in the supplemental report for the Five Mile Creek watershed recognizes the primary interest of the Department of the Interior in the land problems of that watershed because three-fourths of the area in the basin is under the jurisdiction of this Department. Five Mile Creek is a tributary of the Wind River. This Department has in the final stages of preparation a comprehensive report on the Wind River Basin which will present a plan for land improvement, soil erosion control, and reduction in sedimentation for the entire area. Five Mile Creek is one of the worst offenders in the Wind River Basin in terms of its silt load. Consequently, we are glad to endorse the program of the Department of Agriculture for its watershed, subject to the comments in the following paragraphs.

The supplemental report of the Department of Agriculture was discussed with representatives of your Department at a meeting of the Interior Missouri Basin Field Committee on June 20. It was there agreed that there would be close coordination among the field representatives of the two Departments in further planning of measures dealing with the Five Mile Creek problem. We are gratified with this expression of the field representatives, and we intend to implement that collaboration to the greatest possible degree.

The siltation problem of the adjoining Big Muddy Creek is a part of the same segment of the over-all problem of the Wind River Basin. In this circumstance, it would appear that the Department of Agriculture should institute land-protection measures for the Big Muddy watershed similar to those proposed for the Five Mile Creek Basin. One program without the other would mean little in the solution of the total siltation problem.

A large part of the Five Mile Creek watershed is Indian land. The program apparently contains measures to improve the productivity of the Indian lands, to effect runoff dispersion, and to reduce sediment movement. The details of these measures as applied to Indian lands, however, are not apparent in the presentation of the program elements. Here again there is need for close collaboration with this



Department, and it is recommended that the Department of Agriculture work closely with the Bureau of Indian Affairs in developing further plans for program measures on Indian lands and in executing those plans.

#### SOIL SURVEYS AND LAND CLASSIFICATION FOR IRRIGATION DEVELOPMENT

The Department of the Interior also welcomes the proposal of the Department of Agriculture for soil surveys and land classification of irrigable land in the Missouri Basin. As the agency primarily responsible for Federal irrigation development in the Missouri Basin and elsewhere, we are glad to endorse a program for obtaining information on irrigable land, providing that information is developed in a useful manner. Data from soil surveys must be prepared in proper detail if they are to be wholly adequate. Inasmuch as requirements will vary from area to area, mapping details and scheduling should be adjusted accordingly. Also, it must be recognized that a soil survey cannot supply all of the information needed in the classification of irrigable land. Topography and drainage must also be considered in an adequate land classification.

It is recommended that soil surveys and land use capability surveys be integrated. There is as much need for this integration as there is for the correlation of the soil surveys and the land classification carried on by the Bureau of Reclamation. The need for integration between soil surveys and land use capability surveys does not appear to be fully recognized in the report.

It is also recommended that the work proposed by the Department of Agriculture in land surveys and land classification be closely coordinated with the activities of the Bureau of Reclamation in classifying lands in areas proposed to be irrigated in Federal projects in order to avoid duplication of effort.

This section of your report would be strengthened by inclusion of discussion on the status of and need for topographic maps. The Geological Survey can quickly supply this information. The Survey will be pleased to cooperate with the Department of Agriculture in the furnishing of its mapping services, which can make substantial contribution to the soil survey and land classification programs recommended.

We are gratified to note the emphasis in the report on research and the inclusion of estimates of considerable sums for this purpose. We recommend that this research proceed in relation to the substantive program elements so that they can be evaluated appropriately prior to the expenditure of the bulk of the installation funds. This would involve relatively heavy expenditures for research in the early years of the program so that needed data can be obtained for guidance in the installation of the major portions of the programs. Agencies of this Department, particularly the Geological Survey, will cooperate with the Department of Agriculture in the formulation and execution of the needed research programs. The Bureau of Reclamation is in a particularly advantageous position to cooperate in those phases of



the research relating to irrigation by reason of its long experience in this field.

Opportunity to review the report is appreciated.

Sincerely yours,

JOEL D. WOLFSOHN,  
*Acting Secretary of the Interior.*

---

LETTER FROM THE ACTING SECRETARY OF AGRICULTURE TO  
THE SECRETARY OF THE INTERIOR

DEPARTMENT OF AGRICULTURE,  
OFFICE OF THE SECRETARY,  
*Washington, September 18, 1952.*

The honorable the SECRETARY OF THE INTERIOR.

DEAR MR. SECRETARY: Acting Secretary Wolfsohn's letter of August 27, 1952, comments on this Department's supplemental report to the Missouri River Basin agricultural program. We appreciate the thorough study and constructive comments on our report by the Department of the Interior. Your letter illustrates again the merits of the Federal Inter-Agency review process. We feel, however, that some of your comments require an answer in the interest of gaining a more complete understanding of the program recommended in our report.

A number of your comments relate to the adequacy of the data presented in the report for supporting authorization by the Congress. These are well taken because no data justifying our conclusions appear in the report. Greater detail on many aspects of the recommended program is given in House Document 373, Eighty-first Congress, first session, the Missouri River Basin agricultural program, to which the current report is a supplement. The mass of data, technical detail, and other supporting information is not presented in either of the reports but has been assembled in appendixes or in our files. All this material is available on request. We are confident that the available supporting information is adequate to answer most of your comments relative to program justification and appraisal.

Another group of the Department of the Interior's observations are upon aspects of the program which we normally consider and resolve during the detail work planning phase of program development. Examples in this group are the details of planning drainage projects and other aspects of the program to assure the most practicable coordination of agricultural interests with those of fish and wildlife, planning the installation of the program so as to make full use of the facilities of the Geological Survey, and devising methods for the revegetation of strip-mined areas. In this connection, you are correct in assuming that the statements contained in our letter of September 9, 1949, still apply. We assure you that this Department plans to work closely with all interested bureaus of the Department of the Interior, including the Geological Survey, the Bureau of Indian Affairs, and the Fish and Wildlife Service, in carrying out the recommended program.

Several of your comments relate to the effect of the recommended program on water resources. As mentioned earlier, data are available to support the estimates used in calculating damage reductions. In areas, such as irrigated areas, where small differences in water yield are important we expect to investigate further during the work planning stage, the effects of the program on water yield and on other aspects of water supply as needed. We feel that such investigations will be most meaningful when made for individual subwatersheds after the detailed plans are available. Part of this investigation will, of course, deal with water rights including those affected by stock-water ponds. A more complete discussion of these ponds is given in our letter of September 9, 1949.

Other observations were made on the preparation and use of maps. We recognize the value of topographic maps for detail work planning, soil surveys, land classification, and other phases of resource planning. For most of our purposes, however, high order topographic maps are not essential, and we have not recommended, as part of an agricultural program, the preparation of new maps. Where new maps are essential for the work we shall be glad to recommend their preparation by the Department of the Interior and assist in any way that we can toward obtaining them. The need for new maps will depend in part upon the availability of aerial photographs and base maps. Before undertaking any mapping in the upper South Platte watershed for resource inventories, we shall consult with the Department of the Interior for the purpose of making the best use of the facilities of both Departments, avoiding duplication of effort, and devising the most efficient and economical method of obtaining the required maps.

In the supplemental report to the Missouri River Basin agricultural program, as well as in our flood prevention reports we have not broken down the needed measures by classes of ownership, either for lands under the jurisdiction of the Department of Agriculture or the Department of the Interior. In each watershed involving Department of the Interior lands a statement is made in the report giving the Secretary of the Interior authority needed to carry out the program on lands under his jurisdiction. Information on the quantities and measures for all classes of ownership is available either in appendixes or in the files. Negotiations for working out more satisfactory arrangements in these matters are under way between representatives of the two Departments. In the upper South Platte watershed problems on Interior's lands were considered and a program was worked out in consultation with field men of your Department. Our report includes measures on these lands which contribute to flood prevention, but does not include measures for other purposes such as recreation or measures solely for increased timber or forage production.

Your letter points out the need for thorough ground-water studies before beginning irrigation by ground-water pumping in the Salt-Wahoo Creeks and Blue River watersheds. Such studies will be made, and we shall welcome the cooperation offered by the Department of the Interior in conducting them.

Your comment on requiring full repayment for irrigation rehabilitation and betterment work done by the Federal Government suggests a misunderstanding of the recommendations of the report. The work proposed in this category consists of technical assistance, educational

assistance, and direct aids to farmers for work such as rehabilitation and lining of on-farm ditches and the construction on the farm of small irrigation structures. Under legislative authority the Department of Agriculture has been engaged in this work for many years, and the facilities and payments provided through these programs have been made available to all irrigation farmers. The estimated Federal cost of 30 percent of the installation cost is about the average current financial participation in this work. Hence the recommendation in the report does not conflict with existing Federal policy. On the Federal range we understand that a portion of the grazing fees must be used for range improvement.

In our report we set up one or more development farms in the Colorado-Big Thompson project. As is often done, we felt that these farms would also serve as an agricultural research area so that the two functions of demonstration and research could be coordinated. The proposal made in the upper South Platte report conforms to others in the West where the two Departments are cooperating on similar projects. As in the past we would expect the Department of the Interior to cooperate under the terms of memoranda of understanding, to be prepared in advance of the undertaking, outlining mutually acceptable responsibilities of the two Departments. We understand that similar projects are under way on lands not in Government ownership.

Your suggestion of instituting land-protection measures for the Big Muddy watershed adjacent to Five Mile Creek has been considered. We shall give high priority to a survey of this area.

We have studied the need for integrating soil surveys and land use capability surveys conducted by this Department with the land classification work of the Interior Department. To achieve coordination and thus avoid duplication of effort we plan to work closely with the Bureau of Reclamation in planning such surveys.

We appreciate the thorough review given our report and your constructive comments. We hope that the explanations and the more detailed offers of cooperation contained in this letter will give you a basis for your full support of the supplemental report to the Missouri River Basin agricultural program.

Sincerely,

C. J. McCORMICK,  
*Acting Secretary.*





---

---

SUPPLEMENTAL REPORT, MISSOURI  
RIVER BASIN AGRICULTURAL PROGRAM

---

---



# CONTENTS

---

	Page
Recommendations .....	31
Authorities .....	31
Purpose .....	32
Local participation and cooperation .....	33
General provisions .....	34
Recommended program .....	36
Section I. Salt-Wahoo Creeks watershed (Nebraska) .....	38
Section II. Blue River watershed (Kansas and Nebraska) .....	39
Section III. Upper South Platte watershed (Colorado and Wyoming) .....	40
Section IV. Osage River watershed (Kansas and Missouri) .....	40
Section V. Five-Mile Creek (Wind River, Wyo.) .....	41
Section VI. Soil surveys, land classification, and research for irrigation development .....	42





## SUPPLEMENTAL REPORT, MISSOURI RIVER BASIN AGRICULTURAL PROGRAM

---

### RECOMMENDATIONS

It is recommended that—

(a) The Secretary of Agriculture be authorized to carry out all of the recommended accelerated programs set forth in this supplemental report for the watersheds of Salt-Wahoo Creeks, Nebr.; Blue River, Kans. and Nebr.; upper South Platte River, Colo.; Osage River, Mo. and Kans.; Five-Mile Creek, Wyo.; and the program recommended for soil surveys and land classification, except the part which is proposed for installation on land under the jurisdiction of a Federal agency other than the Department of Agriculture; and that the head of such other Federal agency be authorized to carry out the part of the program which is proposed for installation on land under the jurisdiction of such agency. The estimated cost of such programs to the Federal Government is \$246,011,450 and the estimated cost to local interests is \$133,468,290 or its equivalent in labor, material, equipment, land, easements, rights-of-way, and other contributions.

(b) The authority of the Secretary of Agriculture, or the head of any other Federal agency concerned, to prosecute the recommended programs shall be supplemental to all other authority vested in him, and that nothing in this report shall be construed to limit the exercise of powers heretofore or hereafter conferred on him by law to carry out any of the measures described herein or any other measures that are similar or related to the measures described herein.

(c) The Secretary of Agriculture, or the head of any other Federal agency concerned, be authorized to make such modifications or substitutions of the measures set forth in this supplemental report as may be deemed advisable due to changed physical or economic conditions or improved techniques whenever he determines that such action will be in furtherance of the objectives of the recommended programs.

### AUTHORITIES

This supplemental report and the programs set forth in it have been prepared under the provisions of various acts and resolutions relating to the authority of the Secretary of Agriculture to undertake investigations, surveys, research, and programs for the improvement of agriculture.

The following authorities, in particular, are the basis of the coordinated and cooperative effort which has produced the recommended programs described in the supplemental report for the comprehensive agricultural development of the areas involved.

\* \* \* to conduct surveys, investigations, and research relating to the conditions and factors affecting, and methods of accomplishing more effectively

the \* \* \* promotion of the economic use and conservation of land \* \* \* (act of February 29, 1936, as amended (16 U. S. C. 590i)).

\* \* \* to cooperate with Federal, State, Territorial, and other public agencies in developing plans for a program of land conservation and land utilization \* \* \* (act of July 22, 1937 (7 U. S. C. 1011)).

\* \* \* Federal investigations of watersheds and measures for runoff and water-flow retardation and soil-erosion prevention on watersheds shall be under the jurisdiction of and shall be prosecuted by the Department of Agriculture \* \* \* (act of June 22, 1936 (33 U. S. C. 701b)).

Additional authority for this program planning is contained in the act of May 15, 1862 (5 U. S. C. 511-514); the act of April 27, 1935 (16 U. S. C. 590a); the act of June 29, 1935 (7 U. S. C. 427); and the act of May 20, 1936 (7 U. S. C. 902).

Additional authority for investigations and surveys is contained in the following resolutions:

*Resolved by the Committee on Public Works of the House of Representatives, United States, That the Department of Agriculture be, and is hereby, requested to review the reports on the Missouri River Basin, submitted in House Document Numbered 373, Eighty-first Congress, first session, with a view to determining whether any modifications in the recommendations contained therein with respect to the Salt Creek-Wahoo Basin, Nebraska, should be made at this time.*

Adopted, July 19, 1950.

*Resolved by the Committee on Public Works of the House of Representatives, United States, That the Department of Agriculture be, and is hereby, requested to review the reports on the Missouri River Basin, submitted in House Document Numbered 373, Eighty-first Congress, first session, with a view to determining whether any modification in the recommendations contained therein with respect to the Big Blue River watershed, Nebraska, should be made at this time.*

Adopted, July 26, 1951.

*Resolved by the Committee on Public Works of the House of Representatives, United States, That the Department of Agriculture be, and is hereby, requested to review the reports on the Missouri River Basin in Missouri, Iowa, Kansas, Nebraska, South Dakota, North Dakota, Minnesota, Colorado, Wyoming, and Montana, submitted in House Document Numbered 373, Eighty-first Congress, first session, with a view to the modification of recommendations contained therein with respect to the Kansas River Basin in Kansas, Colorado, and Nebraska, the Osage River Basin in Kansas and Missouri, the Blackwater River Basin in Missouri, the Platte River Basin in Colorado, Wyoming, and Nebraska, the Chariton River Basin in Iowa and Missouri, and tributaries of the Platte and Missouri Rivers in Cass County, Nebraska, for runoff and water-flow retardation and soil-erosion prevention.*

Adopted, March 5, 1952.

## PURPOSE

This report is a supplement to the "Missouri River Basin agricultural program" submitted by the Secretary of Agriculture to the Speaker of the House of Representatives on September 29, 1949 (H. Doc. 373, 81st Cong., 1st sess.). That document sets forth a program for the conservation, development, and use of land, water, and forest resources in the Missouri River Basin.

In his letter of transmittal the Secretary of Agriculture set forth the purposes of and need for the program as follows:

It would be carried out under a comprehensive, unified, and multiple-purpose plan especially designed to meet the unique needs of the Missouri Basin. It calls for installation of the needed measures in a definite period of time and for the accelerated effort necessary to accomplish this. In these and other respects, it represents a long step forward in the Nation's approach to the conservation, development, and use of its natural resources.

The proposed program is urgently needed. The Missouri Basin is disadvantaged by droughts, soil erosion, floods, maladjustments in land use, and, in general, the



underdevelopment of its resources, all of which contribute to the insecurity of the basin's people and the instability of their economy.

The need for immediate action is the more pressing because the construction of engineering works is outdistancing programs for the land. Projects for main-stream flood control, irrigation, navigation, and water power must be complemented, supported, and balanced by a program for the land. Costly reservoirs require protection from sediment. The land must be preserved if great engineering works are to serve their purpose and pay for themselves. For these and many other reasons, agricultural and engineering programs must move forward together, and for all these reasons, the Missouri River Basin agricultural program has been designed as the agricultural phase of a comprehensive and multiple-purpose regional program. This insures that it will key into and complement the main-stream projects now authorized, any additional projects that may later be authorized or, in fact, any system of engineering works that might conceivably be undertaken within the basin.

The urgency and basic need for that program has increased in the intervening period since that report was prepared. Growing concern with the problem of reducing flood damages emphasizes the need for initiating remedial measures on upper watershed lands. Intensification of production has put land to harder use, thus increasing the need for intensification of conservation measures in critical areas.

The supplemental report proposes the first stage of installation of the program recommended in the Missouri River Basin agricultural program. This first stage consists of three equally critical and important parts. One is a program of improvement for the watersheds of Salt-Wahoo Creeks, Blue River, upper South Platte River, and Osage River based on estimates of total needed works that will be required to protect and enhance the agricultural productivity of the land and water resources and to make the maximum economical contribution to runoff and water-flow retardation and soil-erosion prevention. A second is a program for the Five Mile Creek area designed to conserve and improve the soil and water resources for sustained productive use. This is one of the most critical problem areas in the Missouri Basin. The third part is an acceleration of soil surveys and land classification in areas now irrigated or under investigation for new irrigation development in seven States of the basin. These investigations are essential to the development of sound irrigation projects.

## LOCAL PARTICIPATION AND COOPERATION

In their design and operating principles the programs recommended in this supplemental report recognize that their success will be determined in the end by the ability and capacity of landowners and operators to fulfill their responsibilities in land and water management and by how well the Federal and State Governments fulfill their obligations for land and water management on public lands. The programs recognize that the Federal Government does not operate directly on private lands except by agreement with landowners. But the programs also recognize that landowners and operators generally are willing to apply the best in practical land and water treatment not only because it assures conservation of land and water resources but also because it increases productivity and contributes to security in land values.

These principles have guided the preparation of the programs. As a result, there is assurance that they will be given the voluntary support and cooperation of landowners and operators, farm groups and



organizations, soil-conservation districts, and other agencies of the States and communities.

The Department of Agriculture will work with the Department of the Interior, the Department of the Army, Corps of Engineers, and other cooperating Federal and State agencies in carrying out these programs.

The Federal Government will share with States, local governments, private landowners, and operators the cost of installing economically sound conservation and land-treatment measures on cropland, grassland, and forest land. Federal assistance will be provided in the form of direct aids, technical services, education and information, and research, and in materials, equipment, and other services. Flexibility in the proportion of Federal assistance is required in order to foster the proper kinds and amounts of measures needed to meet the wide range of problems relating to soil and water.

The annual operation and maintenance costs of land-treatment measures installed on all land except that in Federal ownership will be borne by individuals and by State and local governments, soil-conservation districts, or other agencies under arrangements acceptable to the Secretary of Agriculture. Forest-fire protection will continue to be shared by the Federal Government. Land-treatment measures on Federal land will be installed, operated, and maintained at Federal cost.

The measures for stabilizing small watercourses on Federal land will be installed and operated and maintained at Federal cost, except in those instances where these measures produce direct benefits to non-Federal interests. In the excepted instances, an appropriate share of the costs, as determined by the Secretary of Agriculture, will be borne by the owners of such non-Federal land or other benefited interests.

The recommended measures for stabilizing small watercourses on non-Federal lands are to be operated and maintained by State or local agencies under arrangements acceptable to the Secretary of Agriculture, and installation in any area will not be commenced until such arrangements are made.

Costs of installing measures for stabilizing small watercourses have been calculated on the basis of both Federal and non-Federal participation in installation. While these long-time programs are set up on the basis of the Federal Government taking leadership, it is expected that States and local communities will assume their share of the financial obligations. Flexibility in the proportion of Federal assistance is needed to meet the wide range of conditions under which these installations will be made. State and local governments or responsible local agencies will be urged to participate in the programs to the fullest possible extent.

## GENERAL PROVISIONS

Authorization of the programs recommended in this report would indicate it to be the will of Congress that certain farm, range, forestry, and related activities, being carried out under existing legislative authorities and Nation-wide Federal programs, shall be accelerated and unified in such a way as to complete installations during the time period stated for each watershed area and that certain other measures

for waterflow retardation and control of soil erosion not now a part of regular programs shall also be carried out as a part of each watershed program. This authorization will constitute a basis for requesting the appropriation of funds and for allocating funds in excess of amounts that would normally be requested and used in these areas under regular Nation-wide programs.

It is inherent in the authorization of the programs recommended herein that any funds appropriated for conservation payments that are used to help install measures included in such programs would not be subject to the limitations or requirements applicable to the agricultural conservation program carried out under the Soil Conservation and Domestic Allotment Act, as amended, or under the provisions of the appropriation acts applicable thereto insofar as distribution of funds, maximum payments specified in the appropriation acts, or the increasing of small payments are concerned.

It is recommended that the Secretary of Agriculture, in accordance with such regulations as he deems necessary and when in his judgment the work to be performed will be carried out more effectively, more rapidly, or at less cost than if performed by the Department of Agriculture, be authorized to enter into contracts with such public or private organizations or individuals as he may find qualified to carry on investigation and research as provided for in these programs without regard to the provisions of section 3709, Revised Statutes, and with respect to such contracts make advance, progress, or other payments without regard to the provisions of section 3648, Revised Statutes. Such contracts may be made for work to continue not more than 4 years from the date of any such contract. Notwithstanding the provisions of section 5 of the act of June 20, 1874, as amended (31 U. S. C. 713), any unexpended balances of appropriations properly obligated by contracting with an organization or individual for carrying out any part of these programs may remain upon the books of the Treasury for not more than five fiscal years before being carried to the surplus fund and covered into the Treasury.

It is further recommended that the Secretary of Agriculture be authorized to allot funds to cooperating State agencies in such amounts and under such conditions as he deems appropriate and necessary to carry out the investigations and research outlined in this report in such a way as to most effectively support the action phases of the recommended programs. It is contemplated that, to the extent feasible, the programs of research other than that for the primary purpose of improving the management and use of Federal lands will be accomplished by the existing State agencies in cooperation with the Department of Agriculture with funds allotted under this authority.

It is recommended that the Secretary of Agriculture be authorized, without regard to present limitations in the Bankhead-Jones Farm Tenant Act, as amended, with respect to distribution of funds among the several States and Territories, to obtain and utilize funds in such amounts as may be determined from time to time to be necessary to carry out the loan-making activities proposed in this report.

It is recommended that the Secretary of Agriculture be authorized to carry out in cooperation with the States the types of educational work outlined herein, and that the funds required to supplement the staff available under existing authorizations shall be allotted by the Secretary to the States in such amounts as he deems appropriate.

The measures for stabilizing small watercourses included in the programs recommended for the watersheds of Salt-Wahoo Creeks and the Blue, upper South Platte, and Osage Rivers will be fitted into a practical land and water program for each watershed area. The total costs shown and the distribution of costs between Federal and non-Federal are based on average costs for the entire installation period and are calculated on the basis of long-term projected prices.

The program for each of the watersheds except Five Mile Creek include recommendations for runoff and water-flow retardation and soil-erosion prevention as determined by surveys carried out under authorizations and funds provided through flood-control acts.

The measures recommended for installation in these watersheds are interdependent parts of a whole program for each watershed and will be applied in appropriate proportions and sequence on each field, farm, and subwatershed.

In the watershed reports for Salt-Wahoo Creeks, Blue River, upper South Platte River, and Osage River the measures for stabilizing small watercourses are shown separately. The costs and benefits of these measures are shown separately from the land-treatment measures which also contribute to runoff and water-flow retardation and soil-erosion prevention.

The report on Five Mile Creek proposes a program to deal principally with improving the efficiency in the use of irrigation water and land. Flood hazards are minor in this area compared with the problem of establishing an efficient irrigation project. The credit programs of the Department of Agriculture and the proposed research in irrigation and soil management will have an unusually important role in this area.

In each watershed program provision is made for research, soil surveys, education, and technical assistance and direct aids in proportions that have been determined necessary to get the program installed most economically and effectively. Research completed under the program will have application in other areas of the Missouri Basin.

## RECOMMENDED PROGRAMS

Table I shows the estimated cost of each of the recommended accelerated programs described in the six sections of this report. These programs include the cost of land treatment measures and stabilizing measures, over and above the going programs, necessary to complete the programs within recommended time periods. These costs are calculated on the basis of going programs continuing at current rates.



TABLE I.—*Summary estimated costs, recommended accelerated program*

Watershed area	Federal	Non-Federal Public	Private	Total
Salt-Wahoo Creeks, Nebr.:				
Land treatment measures.....	\$10,781,230	\$337,400	\$8,069,250	\$19,187,880
Small watercourse stabilizing measures.....	6,207,000	1,137,800	477,900	7,822,700
Total.....	16,988,230	1,475,200	8,547,150	27,010,580
Blue River, Kans.-Nebr.:				
Land treatment measures.....	39,201,040	2,900,200	30,543,460	72,644,700
Small watercourse stabilizing measures.....	17,502,400	1,561,700	2,184,900	21,249,000
Total.....	56,703,440	4,461,900	32,728,360	93,893,700
Upper South Platte River, Colo.:				
Land treatment measures.....	39,098,600	678,400	13,275,500	53,052,500
Small watercourse stabilizing measures.....	8,652,200	1,212,800	27,800	9,892,800
Total.....	47,750,800	1,891,200	13,303,300	62,945,300
Osage River, Kans.-Mo.:				
Land treatment measures.....	62,063,100	4,544,700	46,623,900	113,231,700
Small watercourse stabilizing measures.....	55,542,800	-----	17,673,200	73,216,000
Total.....	117,605,900	4,544,700	64,297,100	186,447,700
Five Mile Creek, Wyo.:				
Land treatment measures.....	2,541,780	7,000	2,383,180	4,931,960
Soil surveys, land classification, and irrigation research.....	8,185,000	3,279,000	-----	11,464,000
Grand total.....	249,775,150	15,659,200	121,259,090	386,693,240

For additional information there is set forth in table II a summary of estimated costs of installing the total needed program described in the six sections of the report. These costs include the going programs and the recommended accelerated programs necessary to complete the total needed programs within the recommended time periods.

TABLE II.—*Summary of estimated costs, total needed program*

Watershed area	Federal	Non-Federal public	Private	Total
Salt-Wahoo Creeks, Nebr.:				
Land treatment measures.....	\$13,906,200	\$365,100	\$11,320,900	\$25,592,200
Small watercourse stabilizing measures.....	6,207,000	1,137,800	477,900	7,822,700
Total.....	20,113,200	1,502,900	11,798,800	33,414,900
Blue River, Kans.-Nebr.:				
Land treatment measures.....	62,864,550	3,215,600	45,727,250	111,807,400
Small watercourses stabilizing measures.....	17,502,400	1,561,700	2,184,900	21,249,000
Total.....	80,366,950	4,777,300	47,912,150	133,056,400
Upper South Platte River, Colo.:				
Land treatment measures.....	51,606,800	1,285,500	23,964,500	76,856,800
Small watercourses stabilizing measures.....	8,652,200	1,212,800	27,800	9,892,800
Total.....	60,259,000	2,498,300	23,992,300	86,749,600
Osage River, Kans.-Mo.:				
Land treatment measures.....	113,264,600	5,554,200	115,668,900	234,487,700
Small watercourses stabilizing measures.....	55,542,800	-----	17,673,200	73,216,000
Total.....	168,807,400	5,554,200	133,342,100	307,703,700
Five Mile Creek, Wyo.:				
Land treatment measures.....	3,390,000	77,700	3,055,300	6,493,860
Soil surveys, land classification, and irrigation research.....	9,991,000	3,279,000	-----	13,270,000
Grand total.....	342,927,550	17,689,400	220,100,650	580,688,460

The following is a brief summary of each of the six sections of the report:

### SECTION I. SALT-WAHOO CREEKS WATERSHED, NEBRASKA

A watershed program for this 1,655-square-mile area (1,059,200 acres) in east-central Nebraska is recommended for installation over a 10-year period.

Objectives of the program are to protect the highly productive land from further deterioration resulting from erosion and to correct the misuse of certain other lands, to reduce floodwater and sediment damages, and to increase agricultural production without impairing permanent and sustained productivity.

To carry out the program within a recommended 10-year period will require an acceleration of work above current programs and will require the installation of stabilization measures for small watercourses not included in the current programs. Costs to be borne by the Federal Government are as follows:

	Total needed program	Recom- mended accelerated program
Measures for cropland, grassland, and woodlands (these include such measures as terraces, erosion-control structures, crop rotations, technical service, direct aids, research, and education)-----	\$13, 906, 200	\$10, 781, 230
Measures for stabilizing small watercourses (these include such measures as upstream floodwater-retarding dams, sediment-control structures, and channel improvement)-----	6, 207,000	6, 207, 000
Total-----	20, 113, 200	16, 988, 230

The principal benefits from this program as farm owners and operators apply the practices and measures will be in the form of increased agricultural production and production efficiencies. These will be continuing benefits resulting from conservation of the land resource. At the same time, flood damages on the farms and in the communities will be reduced.

For purposes of economic evaluation, a benefit-cost ratio was calculated for those measures contributing to runoff and water-flow retardation and soil-erosion prevention. It is estimated that the application of these measures would reduce flood damage to land by 82 percent, inundation damage by 61 percent, and sediment damage by 80 percent. This would result in an average annual flood-damage reduction of \$636,200.

These measures would increase production of grain by 22 percent, hay by 100 percent, and pasture forage by 84 percent. This would mean an average annual increase in value of crop production of \$7,511,600, including \$33,700 for increased production on protected bottom lands (land enhancement).

The ratio of benefits to costs for those land-treatment measures contributing to water-flow retardation and soil-erosion prevention is 3.9 to 1. The benefit-cost ratio for stabilizing measures for small watercourses is 2.2 to 1.

## SECTION II. BLUE RIVER WATERSHED, NEBRASKA AND KANSAS

A watershed program for this 9,600-square-mile area (6,144,000 acres) in southeastern Nebraska and northeastern Kansas is recommended for installation over a 20-year period.

Objectives of the program are to conserve the land resource and reduce damages from uncontrolled runoff and sediment. Increased agricultural production which is closely associated with these objectives will result from the application of this program.

To carry out the program within a recommended 20-year period will require an acceleration of work above current programs and will require installation of measures for stabilizing small watercourses not now included in current programs of the Department of Agriculture. Costs of the program to be borne by the Federal Government are as follows:

	Total needed program	Recom- mended ac- celerated program
Measures for cropland, grasslands, and woodland (these include such measures as terraces, seeding pastures, outlets and waterways, erosion-control structures, shelterbelts, research, soil surveys, technical assistance, and education)-----	\$62,864,550	\$39,201,040
Measures for stabilizing small watercourses (these include such measures as upstream floodwater-retarding dams, sediment-control structures, diversion dikes, and floodways)-----	17,502,400	17,502,400
Total-----	80,366,950	56,703,440

Benefits will accrue principally in the form of increased agricultural production resulting from reduced gully and sheet erosion, and more efficient use of land and water resources. In addition, there will be important reductions in flood damages to farms and to communities.

For purposes of economic analysis, benefit-cost ratios were calculated for those measures contributing to runoff and water-flow retardation and soil-erosion prevention. When these measures are applied, it is estimated that flood damage to land will be reduced by 51 percent, inundation damage by 39 percent, and sediment damage by 48 percent. Average annual flood damage will be reduced by \$2,668,900.

As a result of these measures grain-crop production will be increased by 18 percent, hay and forage sorghums by 93 percent, and pasture forage by 45 percent. This will mean about 35 percent increase in feed crops and pasture taken together. This in turn will increase livestock production in the area. Benefits from increased shelterbelt plantings will accrue mostly in indirect form, but wood-lot improvements will yield some increase in wood products. This will mean an increase in average annual value of crop production of \$24,467,900, including \$343,200 for increased production on bottom land (land enhancement).

The ratio of benefits to costs for those land-treatment measures contributing to runoff and water-flow retardation and soil-erosion prevention is 3.6 to 1. The benefit-cost ratio for stabilizing measures for small watercourses is 3.0 to 1.



## SECTION III. UPPER SOUTH PLATTE WATERSHED, COLORADO

A watershed program for this 9,160 square mile watershed area (5,863,000 acres) in east-central Colorado is recommended for installation over a 20-year period.

Objectives of the program are to conserve and develop the land, forest, and water resources; improve management of these resources which will contribute to the reduction of flood damage; enhance water quality and supply; and balance and complement resources programs of other agencies.

Installation costs to be borne by the Federal Government are as follows:

	Total needed program	Recommended accelerated program
Measures for cropland, grassland, and forests (these include such measures as reseeding ranges, erosion-control structures, forest planting, forest protection and improvement, irrigation, land leveling, ditch lining, timber stand improvement, research, and education)-----	\$51,606,800	\$39,098,600
Measures for stabilizing small watercourses (these include such measures as detention dams and sediment-control structures)-----	8,652,200	8,652,200
Total-----	60,259,000	47,750,800

Improved efficiencies in water and land use will appear soon after improved practices are applied. Long-time benefits will accrue from more intensive management of forests and range resources, and from the gradual increase in land productivity. Damages from floods and sediment will be reduced and other benefits will accrue as increased forest and agricultural products increase in volume and stability.

A high proportion of this watershed area is in national forests and other public ownership. From the forests and forest range lands and foothill and mountainous portions of the watershed comes a very high proportion of the water so important to the economy of the entire watershed area. Benefits from application of measures proposed will protect and enhance the vital water storage and regulatory function of the high watershed lands.

For purposes of economic analysis, benefit-cost ratios were calculated for those measures contributing to runoff and waterflow retardation and soil erosion prevention. When these measures are applied, flood damage will be reduced by \$495,500 annually. The same measures will increase annual production of crops, grass, and forests by \$949,500.

The ratio of benefits to costs for those land-treatment measures contributing to runoff and waterflow retardation and prevention of soil erosion is 2.7 to 1. The benefit-cost ratio for stabilizing measures for small watercourses is 1.1 to 1.

## SECTION IV. OSAGE RIVER WATERSHED, KANSAS AND MISSOURI

A watershed program for this 15,300 square mile watershed area (9,792,000 acres) in east-central Kansas and west-central Missouri is recommended for installation over a 20-year period.

Objectives of the program are to preserve and enhance the productivity of land, water, and forest resources and to reduce flood damages to farms and communities.

Installation costs to be borne by the Federal Government are as follows:

	Total needed program	Recom- mended accelerated program
Measures for cropland, pasture land, and woodland (these include such measures as seeding grasses and legumes, terraces, outlets and waterways, tree planting, forest fire protection, farm drainage research, technical assistance, and education)-----	\$113, 264, 600	\$62, 063, 100
Measures for stabilizing small watercourses (these include such measures as upstream floodwater-retarding structures, stabilizing and sediment-control structures, and channel improvement)-----	55, 542, 800	55, 542, 800
Total-----	168, 807, 400	117, 605, 900

The installation and maintenance of this program will increase production of all major crops. It is estimated that total feed crops (grain, hay, and pasture) will be increased by 82 percent. An increase in livestock production is expected to result from this change. Increased timber production and benefits associated with improved forests will accrue from improvement of the large forest area in this watershed. Flood damages will be reduced substantially by beginning the control of surface water on the upper watershed where it begins to accumulate.

For purposes of economic evaluation, a benefit-cost ratio was calculated for those measures included in the program that contribute to runoff and waterflow retardation and soil-erosion prevention. It is estimated that the installation of these measures will increase the average annual value of crop production, pasture, and forest land production by \$39,826,000, which includes \$518,000 from increased production of protected bottom lands. In addition, a reduction in flood damages of \$3,115,900 annually will be gained as a direct benefit.

The ratio of benefits to costs for those land-treatment measures contributing to runoff and waterflow retardation and prevention of soil erosion is 3.33 to 1. The benefit-cost ratio for stabilizing measures for small watercourses is 1.53 to 1.

#### SECTION V. FIVE MILE CREEK WATERSHED

A special program for this 407-square-mile watershed area (260,480 acres) in central Wyoming is recommended for installation over a 10-year period.

The objectives of the program are to arrest the decline in loss of irrigated land through seepage; improve efficiency in the use of irrigation water; stabilize production and the economy of an irrigation project that is not yet firmly established; fit irrigation in with the range economy of the area; and reduce sediment damage now arising from misuse of irrigation water.

Installation costs to be borne by the Federal Government are as follows:

	Total needed program	Recom- mended accelerated program
Measures for crop land and pasture land (these include such measures as irrigation, land leveling, lining ditches, irrigation structures, erosion-control structures, credit, research, and education)-----	\$3, 312, 042	\$2, 541, 777

Approximately 336 acres are now being lost annually from seepage and salinity. This loss will be reduced by 200 acres annually. The installation of measures and works of improvement will result in the following measurable average annual benefits:

Increased production from crop and range-----	\$799, 500
Value of investment in improvements appurtenant to land saved from seepage and salinity-----	52, 200
Total-----	851, 700

#### SECTION VI. SOIL SURVEYS, LAND CLASSIFICATION, AND RESEARCH FOR IRRIGATION DEVELOPMENT

This section of the report recommends a program of soil surveys for land in the Missouri Basin now under investigation for potential irrigation or now lying within irrigation projects needing rehabilitation and improvements. These are needed not only to select land for irrigation, but to choose crops, cropping systems, irrigation methods, and soil management practices for the land that is to be irrigated.

There is need to provide an adequate soil inventory on 7,285,000 acres within the next 10 years. The estimated cost is \$4,736,000. This will require \$2,240,000 in addition to funds available at the current rate of expenditure over the 10-year period.

Also recommended in this section of the report is research urgently needed in irrigation development to keep abreast of demands for expanding irrigation into new areas and to solve the problems of old irrigation areas. Heavy investments of public funds for irrigation systems and heavy investments by individual farmers in irrigation farms make it imperative to start this research promptly.



# SECTION I

## SALT-WAHOO CREEKS WATERSHED (NEBRASKA)

### CONTENTS

	Page
Scope of report.....	45
Description of watershed.....	45
Economic development.....	49
Watershed problems.....	53
Current status of work.....	58
Desirable pattern of land use.....	60
Total needed program.....	61
Program appraisal.....	73
Recommended accelerated program.....	77

### LIST OF TABLES

Table	
1. Drainage area of Salt Creek by counties.....	45
2. Major tributaries of Salt Creek.....	46
3. Present land use.....	50
4. Average annual damage.....	58
5. Land use, agricultural land, present and planned.....	61
6. Estimated Federal cost of research.....	72
7. Total needed program.....	73
8. Recommended accelerated program.....	78



## SECTION I

### SALT-WAHOO CREEKS WATERSHED (NEBRASKA)

#### SCOPE OF REPORT

There is set forth in this section a program for the conservation, development, and use of the lands of the Salt-Wahoo Creeks. The principal objectives are: To protect the highly productive lands from further deterioration resulting from the ravages of erosion and to correct the misuse of certain other lands; to increase the agricultural production without impairing permanent and sustained productivity; and to reduce the floodwater and sediment damages which occur annually in this watershed. It is the purpose of this report to describe the Salt-Wahoo Creeks watershed, to set forth the elements of the recommended program and its costs to accomplish the stated objectives, and to appraise the benefits and results that will come from its application and installation.

The report provides a reliable basis for recommending approval of the watershed programs, and will provide a satisfactory framework for the preparation of annual work plans for accelerating certain phases of work and initiating the installation of other needed measures that will not be carried out under current programs of the Department of Agriculture.

#### DESCRIPTION OF WATERSHED

##### LOCATION AND SIZE

The watershed of Salt Creek, a tributary of the Platte River, has a drainage area of 1,655 square miles. It is located in southeast Nebraska and includes nearly all of Lancaster and Saunders Counties and small areas of Butler, Cass, Saline, and Seward Counties (table 1).

TABLE 1.—*Drainage area of Salt Creek by counties*

County	Drainage area		
	Square miles	Acres	Percent of total area
Lancaster.....	778	497,824	47.0
Saunders.....	646	413,078	39.0
Cass.....	86	55,078	5.2
Seward.....	84	54,019	5.1
Butler.....	56	36,013	3.4
Saline.....	5	3,179	.3
Total area.....	1,655	1,059,191	100.0

The principal headwater tributaries converge in the close vicinity of Lincoln to form Salt Creek proper which flows through that city in a northeasterly direction to its junction with the Platte River a few



miles below the town of Ashland. Wahoo Creek, largest of its tributaries, joins Salt Creek just a few miles above its junction with the Platte. The watershed is roughly rectangular, measuring approximately 63 miles in length and 39 miles in width near the center, its widest point. Map 1 shows the drainage pattern and location of the watershed.

#### PHYSICAL CHARACTERISTICS

The watershed lies within the physiographic subdivision known as the loess-drift hills region of Nebraska.<sup>1</sup> Topograph ranges from nearly level to hilly, corresponding in a general way to the relief of the old eroded Kansas drift which comprised the surface mantle in the watershed prior to the deposition of loess materials by wind action. The areas of greatest relief are along Oak Creek and its tributaries, along the upper headwaters of Rock and Middle Creeks, Holmes Branch, Olive Branch, upper Salt Creek above Hickman, and upper Wahoo Creek. The average elevation of the uplands is about 1,400 feet above mean sea level, ranging from 1,520 feet on the high divides in the headwaters above Lincoln to 1,067 feet at Ashland near the mouth of Salt Creek.

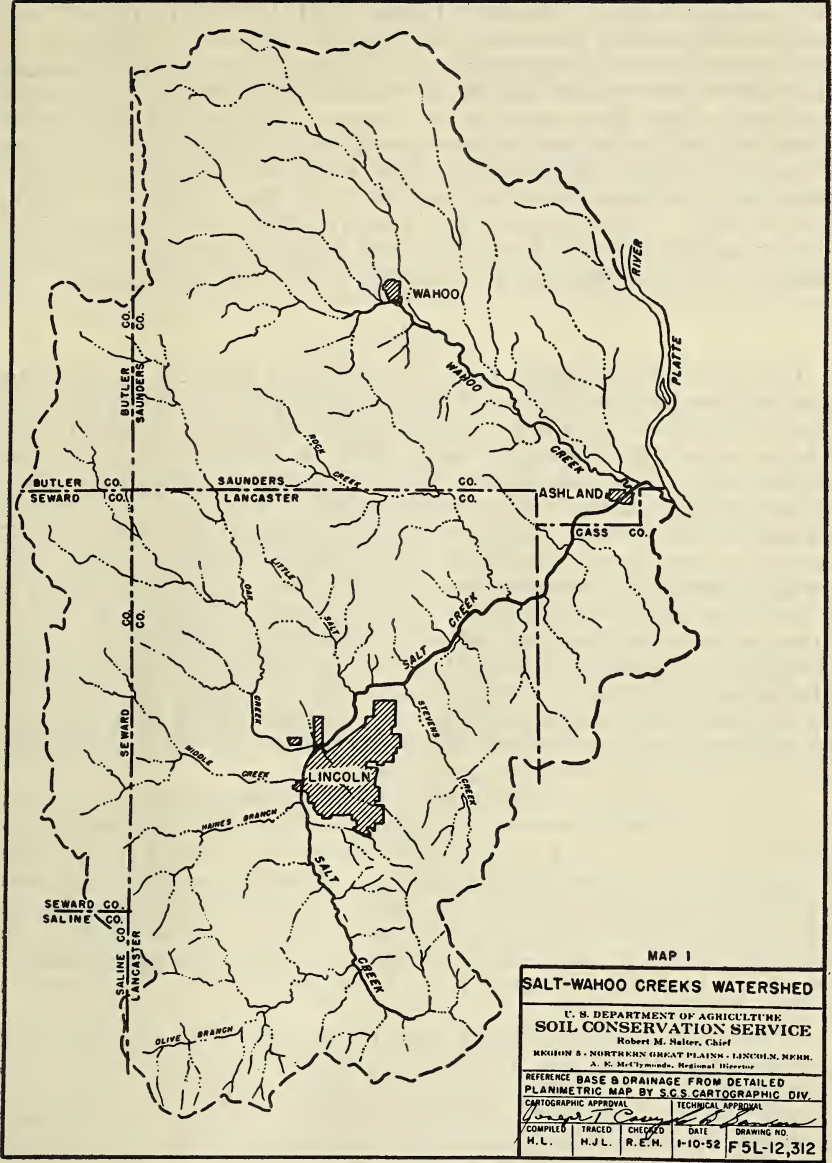
Channels of the main stream and its principal tributaries above straightened sections are well-defined, meandering, and ordinarily quite stable. The banks of these streams are in general built up 1 to 2 feet higher than the adjacent lands as a result of repeated overflow with accompanying deposition of sediments. Table 2 lists the principal tributaries to Salt Creek with the drainage area in square miles.

TABLE 2.—Major tributaries of Salt Creek

Stream name:	Drainage area (square miles)
Olive Branch.....	108
Haines Branch.....	65
Middle Creek.....	102
Oak Creek.....	249
Rock Creek.....	140
Little Salt Creek.....	43
Wahoo Creek.....	473
Stevens Creek.....	52

Alluvial lands, including stream terraces and flood plains, have been extensively developed along the main stem and principal tributaries. The terraces lie 10 to 30 feet above the bottom lands and few of them are subject to inundation by overflow from the streams. In most places the transition from the terraces to the flood plains, or first bottoms, is marked by a short steep slope. The first bottoms occupy broken or continuous strips bordering all the larger and many of the smaller drainages. They lie only a few feet above the channel bottoms and are subject to frequent overflow. The bottoms along Salt Creek and its larger tributaries reach widths exceeding a mile in several places, but elsewhere they range in width from a few rods to about half a mile. The surface of the flood plain is nearly level with shallow depressions occurring along some stretches, particularly along the main stem between Lincoln and Ashland and along Little Salt and Rock Creeks. These depressions range up to 6 or 7 feet in depth and some of them maintain relatively high-water levels the year around as a result of seepage augmented by runoff from surrounding lands.

<sup>1</sup> Condra, G. E., and Reed, E. C. The Geologic Section of Nebraska. Nebraska Geological Survey, Conservation and Survey Division, University of Nebraska, Bulletin 14, 82 pp., illus., 1943.



## GEOLOGY

Surface formations in the watershed consist for the most part of materials laid down during Pleistocene time. Wind-deposited materials mainly silts of Peorian (Upper) and Loveland (Lower) age, occupy the surface positions over most of the area. Extensive exposures of drift of the Kansas glaciation are to be found on the uplands throughout the western half of the watershed where the loess mantle is absent or has been removed by erosion. Bedrock of Cretaceous, Permian, and Pennsylvanian age are exposed in widely scattered areas along the steeper valley sides. The Cretaceous exposures consist principally of limestones, sandstones, and clay shales of variable permeability. The Permian and Pennsylvanian rocks consist principally of interbedded limestones and shales of generally low permeability except where they are deeply weathered or fractured.

## SOILS

The soils of the watershed may be combined into four fairly homogeneous groups on the basis of origin and/or position in which developed. Group 1 includes predominantly deep and medium deep friable soils. They occupy nearly level to rolling topography and slopes range from less than 2 to 10 percent, with 2- to 5-percent slopes predominating. About 42 percent of the watershed land is classed in this group. Group 2, about 35 percent of the watershed, combines mainly soils developed on the glacial uplands. These soils occupy topography ranging from nearly level to hilly, with slopes of 5 to 10 percent predominating. Group 3, about 12 percent of the area, is comprised entirely of soils occupying nearly level terrace positions, and group 4, about 11 percent of the area, includes mainly alluvial soils of the first and second bottoms. These are very dark to black soils developed from alluvium washed mainly from adjacent loessial and glacial uplands. They are among the most productive soils in the region for crop production.

Prior to settlement of the area, the uplands supported a luxuriant growth of tall prairie grasses which had a marked effect on the development of the soils. As a consequence, most of the upland soils, except for those on the most steeply sloping and severely eroded areas, are very dark, highly granular in the surface layers, friable throughout, and easily penetrated by air, roots, and water. Virtually all of the soils have a high moisture-holding capacity, but few are porous enough to absorb more than a small part of the precipitation as rapidly as it falls.

Runoff from most cultivated areas in the watershed is rapid under prevailing practices and much of the topsoil has been removed by sheet erosion. The average depth of topsoil remaining on the cultivated lands is estimated at less than 5 inches. Gully erosion presents a serious problem in some areas, and particularly on the more steeply sloping cultivated lands.

## CLIMATE

Temperatures and precipitation between winter and summer vary rather widely in the Salt-Wahoo Creeks watershed. The spring seasons as a rule are cool and rainy and the summers are long with



warm days and nights. Such weather favors rapid growth of small grains and is especially favorable to the growth of corn. Only occasional periods of rainy weather occur in the fall. Low temperatures in the winter are usually of short duration.

The average date of the last killing frost is April 18 and that of the first is October 15. This gives an average frost-free season of 180 days, which is ample for maturing and harvesting the crops commonly grown in the area.

The annual precipitation averages 27.94 inches with about 83 percent falling during the growing season, April to October. The annual snowfall averages 24.3 inches, which is equivalent to about 2 inches of rainfall.

The prevailing wind is from the north during the period February 1 to May 1. The rest of the year it is from the south. The average annual wind velocity is 10.5 miles per hour and the relative humidity averages 64 percent.

#### NATIVE VEGETATION

Prior to the arrival of settlers in the watershed nearly all of the uplands supported a luxuriant growth of prairie grasses composed principally of such varieties as little bluestem, needle grass, side oats grama, June grass, and prairie drop seed. Big bluestem, Indian grass, and wild rye were found abundantly on the better drained bottom lands. These same grasses prevail today in the well-managed and relatively undisturbed virgin sod areas.

Woodland areas are confined to narrow, discontinuous strips along the drainage ways and to valley slopes in scattered localities. Growing timber is largely unmerchantable due to repeated cuttings, poor cutting practices, grazing, and other destructive factors. Principal species are elm, ash, cottonwood, and box elder in the lower areas, and bur oak on the steeper slopes. Since settlement, the plantings have been chiefly for shelter of livestock and farmsteads and to provide fuel and posts.

#### ECONOMIC DEVELOPMENT

##### HISTORY

Settlement of the watershed was begun around 1856 by settlers who came mainly from Iowa, Illinois, Indiana, Missouri, Pennsylvania, and other States to the east. Most of them were American-born of German, Dutch, Irish, and Swedish descent.

Early settlement was sporadic until 1859 when the Overland Trail to the West was changed to a more direct route through the area.

The first settlers located along the streams where water and wood for fuel and other uses could be readily obtained. Homesteading spread rapidly to the surrounding uplands after the more desirable valley bottoms were settled. The soils for the most part are highly productive and virtually all of the original prairie sod has at one time or another been broken for crop production.

The first crops grown were corn, potatoes, flax, and garden vegetables for home use. Present-day agriculture is diversified, consisting mainly of the growing of corn, grain, and hay, and the feeding of livestock. Wheat is the principal cash crop, with corn, oats, and legumes as other principal crops grown mainly for feed on the farms.

The early settlers took advantage of the protection and products offered by the existing woodland cover in selecting their home sites. Many of the early settlers planted trees around their farmsteads for beautification and protection purposes. The general interest in trees resulted in the creation of Arbor Day in Nebraska in 1872. The Clarke-McNary Act, which was passed in 1924, authorized Federal and State cooperation in farm plantings. The establishment of the Prairie States forestry project in 1935 accelerated the planting of trees in rural areas.

Lincoln, the State capital, located near the upper headwaters of Salt Creek, ranks second in the State as an industrial center. Agricultural products such as meat and flour are the principal items processed. Other items of manufacture are farm machinery, construction materials, tools, furniture, home furnishings, clothing, beverages, tobacco, and candy.

#### POPULATION

The total population of the watershed, based on preliminary census figures for 1950, is estimated at 135,500, of which approximately 33,300, or 25 percent, live on farms and in towns of less than 1,000 population. This represents a rural population density, including the smaller towns, of 20 persons per square mile. The actual farm population is estimated at about 11 per square mile based on 1945 agricultural census data. Lincoln, the State capital and county seat of Lancaster County, has a population of approximately 100,000. Wahoo, county seat of Saunders County, is the second largest city in the watershed. It has a population of over 3,000. Ashland, a city subject to frequent flooding from Salt Creek, is the third largest city in the watershed with a population of about 1,700. It is located in Saunders County on Salt Creek, just a few miles above its mouth.

#### PRESENT LAND USE

According to reconnaissance conservation surveys, 774,492 acres, or over 73 percent of the watershed area, is presently under cultivation (table 3).

TABLE 3.—*Present land use, Salt-Wahoo Creeks watershed*

Item	Watershed	Percent
Number of farms.....	5,500	-----
Square miles in area.....	1,655	-----
Total acres in area.....	1,059,200	100.0
Acres in cultivation.....	774,500	73.1
Acres in pasture and meadow.....	208,900	19.7
Acres in woodland.....	14,000	1.3
Acres in wasteland and abandoned land.....	18,600	1.8
Acres nontreatable.....	43,200	4.1

Of this amount, 44 percent is devoted to the production of row crops, predominantly corn; and 40 percent to small grains, mainly wheat. The balance of the cropland is in legumes and grasses. Native meadow and pasture make up about 20 percent of the total area and the balance is in farmsteads, cities, towns, roads, etc.

The lands classified as woodlands comprise about 14,000 acres, a small amount of which is composed of farmstead windbreaks, hedge-

rows, and wildlife plantings. Largely adjoining but also intermingled with the existing woodlands are irregular areas, many of which are idle or providing limited grazing use. Many of these lands are well adapted to the growing of valuable tree species and can best be utilized for this purpose.

#### LAND OWNERSHIP AND TENURE

According to the 1945 agricultural census, 47 percent of the farms embracing 63 percent of the area is operated by tenants and part owners and the balance by full owners. A considerable acreage is owned by interests living outside the watershed. A comparison of census figures shows an approximate loss of 150 farms per county for all counties in the watershed between the years 1940 and 1945. This has resulted in an increase in the average size of farms in the watershed.

A total of 17,324 acres is included within the Mead Ordnance Plant, a federally owned establishment. Approximately 13,000 acres of this amount is presently being farmed. The only other publicly owned land of any considerable extent is a tract of about 1,300 acres included in the former Lincoln Army Air Base, now owned by the city of Lincoln.

#### TYPE AND SIZE OF FARMS

The 1945 agricultural census classifies 20 percent of the farms as livestock farms, 53 percent as crop farms, 23 percent general farms, and 4 percent subsistence units. Seventy-two percent of the farms are 140 acres or larger in size, 28 percent contain less than 140 acres, and 15 percent contain less than 90 acres. The average size of farms in the watershed has been on the increase in recent years. In 1940 they averaged 175 acres and in 1945, 185 acres. The smaller units are incorporated into larger farms both by purchase and by renting.

#### WATER SUPPLY AND USE <sup>2</sup>

Water of generally good quality in sufficient amounts for family and livestock needs and to meet requirements of smaller towns is quite readily obtainable over most of the watershed. In the upland areas it comes mainly from lenses and buried channels of sand and gravel in the glacial-drift deposits and from sandstone bedrock at depths of 40 to 100 feet. In a few places water is obtained from limestone and sandy shale formations, but this supply is limited and uncertain. Most of the water obtainable is medium-hard in character. The depth to water in the uplands depends partly upon the character of the relief and thickness of the loessial cap where present, but mainly upon the thickness and textural composition of the drift deposits and on the depth to suitable bedrock aquifers. As a general rule, water obtained at a depth of more than 250 feet below the level of the uplands is too salty to drink.

Water is obtainable in abundance from sandy stream-laid deposits at depths of from 20 to 30 feet throughout most of the bottom-land areas. However, much of the water from wells along Salt Creek and the lower courses of its larger tributaries is salty. Elsewhere in tributary streams the water is of good quality. Some water of good

<sup>2</sup> Soil Survey Bulletin, Lancaster County, Nebr., series 1938, No. 15, May 1948. USDA, University of Nebraska cooperating.



quality is obtainable from springs at or near the contact of the drift and bedrock formations.

The city of Lincoln obtains an abundance of good quality water from the Platte River sands at a distance of some 30 miles or more. The pumping stations for the city are located at Ashland, near the mouth of Salt Creek.

Animal wastes and refuse from feed lots and barnyards is an important source of organic pollution.

Streams in the watershed provide limited supplies for livestock. Most of them are intermittent and are dry most of the year. The waters in some of the streams that do have a fairly steady flow are not potable, even for livestock, because of high salt or silt content or other pollution.

There are no lakes of any consequence for recreational purposes in the watershed. Salt Lake, near Lincoln, maintained by flows from salt wells, provides limited recreation. A few small artificial lakes scattered throughout the watershed provide some water for livestock and local recreation.

#### RECREATIONAL DEVELOPMENT

There are no recreational areas or facilities of any consequence in the watershed or in close proximity to the watershed except those provided in the way of parks for picnicking. The largest of these is Pioneer Park at Lincoln, which was established and is maintained by that city. Salt Lake, also at Lincoln, provides limited fishing, as does Salt Creek and one or two small artificial lakes or ponds which are kept stocked by the State game commission.

A great need exists not only in the watershed but in this entire section of Nebraska for the development of facilities which will provide recreation both during winter and summer.

#### TRANSPORTATION AND COMMUNICATIONS

The watershed has good transportation facilities and no part of the area is more than 7 or 8 miles from a shipping point. There are approximately 175 miles of hard-surfaced Federal highways traversing all sections of the watershed and many more miles of good gravel roads. Five railroads, the Chicago, Burlington & Quincy; Chicago, Rock Island & Pacific; Union Pacific; Chicago & North Western; and the Missouri Pacific serve all parts of the watershed with a total of approximately 380 miles of trackage. Main lines of the Chicago, Burlington & Quincy and the Chicago, Rock Island & Pacific pass through Lincoln and Ashland. Branch lines of the other roads pass through or have their termini in Lincoln. The Chicago, Burlington & Quincy is the biggest operator, with roughly 177 miles of track. The Union Pacific has about 82 miles of track, the Chicago & North Western 46, the Chicago, Rock Island & Pacific 39, and the Missouri Pacific 36 miles.

Commercial and municipal airports are located at Lincoln. United, Mid-Continent, and Mid-West Airlines operate out of Lincoln, and provide regular service for this area.

Electric power, telephone, and telegraph services are available to all parts of the watershed, and many radio stations serve the area. Five radio stations are located in the city of Lincoln and plans call for the establishment of one or two television stations.

### WATERSHED PROBLEMS

High demand for agricultural products, particularly grain and livestock products, during and immediately following World Wars I and II, resulted in intensive cropping of the land in this watershed. The present and foreseeable future high demands for agricultural production require immediate acceleration of the application of conservation measures and proper land-use adjustments if the farmers are going to be able to maintain or increase the productive capacity of their farms. The same measures that will sustain or increase agricultural production will, to an important degree, also reduce the damaging effects of floodwater runoff and sediment.

The condition of the watershed land, reflected in its productive capacity and its ability to absorb moisture, has been continuously declining since the area was first settled. The deterioration of these conditions has been brought about by misuse and mismanagement of the land, including such practices as cultivating land that is too steep, farming up and down the slopes, burning of crop residues, and the overgrazing of grasslands. The actual decline in production from this watershed through the loss of topsoil by erosion and through improper cropping systems has been in part offset and the effects obscured by the introduction of improved crop varieties and increased use of commercial fertilizers. The improvement in crop varieties and the use of commercial fertilizers cannot, however, be expected to keep pace with the continued decline resulting from the misuse of the land. Further the changes in these watershed conditions as they affect the ability of the soil to absorb and retain moisture cannot be offset by those practices that increase production. There is evidence within the watershed that there has been an increase in the frequency of flooding, both on the small tributary streams and on the major flood plains. A program providing for the proper use and treatment of the lands of the watershed will provide for the maintenance of permanent productivity and protection of the area from erosion and the damages from uncontrolled runoff.

Severe storms in recent years and particularly those causing the floods of May 8-9, 1950, and June 1, 1951, have focused the attention of the people of the area on the problem of reducing erosion and controlling runoff waters from the watershed lands.

It is believed that farmers generally are fully aware of the seriousness of the erosion problem in the watershed. The severity of soil losses, resulting particularly from intense storms experienced in the summer of 1947 and again in the spring of 1950, has made them cognizant of the immediate and urgent needs for control measures. All of the counties in the watershed are organized into soil-conservation districts and requests by farmers for assistance in planning conservation programs for their farms far exceed the technical assistance presently available for this purpose.

### FLOOD PROBLEMS

Floods are known to have occurred in the Salt-Wahoo Creeks watershed from the advent of the earliest settlers. The most serious floods of record are those which were produced by the storms of July 1908, May 1942, May 1950, and June 1951. There have been numerous



but less severe floods on the major flood plains of Salt Creek, and there is flooding in some reaches of the minor tributaries of the watershed almost every year. The general shape and the drainage pattern of Salt Creek is conducive to a serious flood problem. Five major tributaries converge in the vicinity of Lincoln—upper Salt Creek from the south; Haines Branch from the southwest; Middle Creek from the west; Oak Creek from the north; and Antelope Creek and Deadman's Run from the east. These tributaries converge and flow in a northeasterly direction toward Ashland, where Salt Creek is joined by Wahoo Creek just above its mouth at the Platte River.

The watershed is subjected to intense rainfall occurring in thunderstorms during the spring and summer seasons. Flooding occurs wherever such a storm is centered, and when the storm is of such size to produce high flows in several of the tributaries at the same time, floods of considerable magnitude occur on the main stem of Salt Creek. Damages from these flood-producing storms occur first on the upland areas in the form of sheet and gully erosion, washed-out crops, and delays in seeding for cultivating crops. The runoff waters from the upland fields overflow the channels and inundate approximately 87,100 acres of flood-plain lands, causing damage to the land itself, to crops and other agricultural property, to urban and industrial developments, and to roads and railroads. In addition to these damages, there are many indirect damages which occur as a result of the floods. They include such items as disruption of normal activity in the flooded area and the surrounding region; loss in weight and condition of livestock; loss of wages; spreading of noxious weeds; depreciation in property values; decreased efficiency in use of labor and machinery; disruption of traffic, and many other economic disturbances.

#### FLOOD DAMAGES

The average annual flood damages which have been estimated for the Salt-Wahoo Creeks watershed are presented in table 4. The damages have been grouped into four major classifications: (1) inundation damage; (2) land damage; (3) sediment damage; and (4) indirect damages, and the value of the damages as shown is based on long-term projected prices. In the following paragraphs, each of these categories of damages is discussed:

##### *Inundation damage*

*Agricultural.*—Agricultural damages evaluated consist of damage by floodwater to crops and pastures; to farm improvements, including farm buildings and contents, fences, farm roads and bridges, farm machinery, livestock, and stored hay and grain. The flooding of growing crops and pastures comprises the major agricultural damage in the watershed. Such damage includes the complete loss of crops in some cases and the reductions in yields following a flood in others. The following factors are also important considerations in determining these flood damages: (1) reduction of yields due to a delay in planting; (2) lower income resulting from planting less desirable crops; (3) increased costs of tillage operations; and (4) the costs of replanting all or portions of flooded fields. The grazing capacity of pastures is greatly reduced by inundation, particularly along the larger streams where the period of inundation is prolonged. The infestation of



fields and pastures by weeds following a flood period also results in a decrease in production. Debris carried by the floodwaters and deposited on cropland entails the cost of removal and frequently delays planting operations. Fence damage is widespread and results in large expenditures for labor and materials for repair or replacement. Although many farmsteads are located on the flood-plain land adjacent to the stream channels, the damage to farm buildings, loss of stored hay and grain, and the loss of livestock and poultry during floods are not major items in the damage appraisal. The average annual agricultural damage due to inundation is estimated to be \$342,700.

*Nonagricultural.*—Nonagricultural damages include that which occurs in the urban areas of the watershed; to the roads and highways; to the bridges and culverts; and to railroads. In the urban areas, homes and business establishments are flooded, the buildings and their contents destroyed or damaged, and their occupants are forced to leave. Yards and streets are covered with silt and debris; and streets, railroads, and bridges are damaged or destroyed. Power and communication interruptions also contribute to the flood losses. The cleaning up of homes and business buildings following a flood is a costly item. Flood damage to roads and highways is one of the largest single damage evaluated in this watershed. There is a highly developed system of roads, and the frequent flooding of small tributary streams results in a very costly maintenance program. The cost of replacing road fills that have been washed out, the regrading of road ditches which have been filled with silt, the removal of deposits of silt from the road surfaces, and the replacement of gravel and rock which is washed off the roads during flood periods constitutes this maintenance program. The replacement of bridges and culverts which are washed out by the floodwaters and the repair of those which have been damaged is another significant item in the annual budget for all of the counties within the watershed. Road, bridge, and culvert damages within the city of Lincoln have been included in the estimate of urban damages. The railroads operating lines into Lincoln have experienced some very costly repairs following almost every major flood. These floods wash out embankments and remove ballast from the roadbed, delay traffic, and in many cases cause the rerouting of trains for prolonged periods. The total average annual inundation damage to nonagricultural property is estimated to be \$562,100.

#### *Land damage*

*Sheet erosion.*—Sheet erosion is a problem of particular concern in most parts of the watershed. The removal of the thin capping of highly productive loess is exposing the undeveloped and much less productive underlying glacial and residual soil materials. This soil erosion has permanently reduced the productivity of much of the watershed. In some places and in association with gully erosion, it has exposed areas of infertile sediments. This is noted in the Wahoo Creek portion where very sandy soil is now being removed and carried downstream. Besides the effect of reducing the productivity of the area and adding to the sediment load of the stream, sheet erosion seriously affects the ability of the soil to absorb moisture and store water. Since the principal damage by sheet erosion is that reflected by the reduction of the productivity of the land, the evalua-

tion of this damage is contained in the estimate of the gross increase in income from the lands of the watershed which can be expected following the application of the program. This increase in gross income is termed the "conservation benefit."

*Gully erosion.*—Gullies are destroying an estimated 355 acres of land each year in the Salt-Wahoo Creeks watershed. A much larger acreage has been depreciated because of the dissection and subsequent restrictions of use for cultivation. Even though badly dissected cropland may not be soon abandoned, the increased costs of operation eventually make continued cultivation of such areas unprofitable. The loss of income because of increased costs of production and lower productive land use is evaluated with the conservation benefits. The damage estimate specifically for gullies reflects only the gully voids and the turnrow strips adjacent to the gullies on cultivated lands which cannot be farmed. The residuum of gully erosion is evaluated under sediment damages. Active gullies from 20 to 30 feet in depth occur in some of the more steeply sloping areas in the western and northwestern part of the watershed. In some cases such gullies have cut deeply into infertile sandy materials and are the source of considerable sediment damage along the stream bottoms and particularly along Wahoo Creek. The residuum of gully erosion is evaluated under sediment damages. Gully erosion is estimated to cause \$39,000 damage annually.

*Stream-bank erosion.*—Stream-bank erosion is removing an estimated 21 acres of bottom land from production each year. It occurs throughout the watershed, with the rate of destruction usually greater on the larger streams. It is estimated that there is \$4,100 average annual damage by stream-bank erosion.

*Flood-plain scour.*—Flood-plain scour is prevalent throughout the watershed and particularly along the larger streams. It is estimated that every year the productive capacity of an additional 71 acres is reduced by 20 percent. This loss is valued at \$2,300 annually.

#### *Sediment damage*

The products of soil erosion impair productivity of the bottom lands, reduce the storage capacity of reservoirs, and damage transportation facilities. The principal source of harmful sediment is sheet erosion with gully erosion, stream-bank erosion, and flood-plain scour contributing to a lesser degree. Harmful sediment deposits are constantly reducing the productive capacity of some of the flood plains and thereby reducing the income from this land.

*Deposition damage.*—Sediments of a less fertile or harmful nature have been deposited on some of the flood-plain lands. It is estimated that each year this deposition is reducing the productive capacity by 8 percent of an additional 995 acres of bottom land. This type of damage occurs throughout the watershed, with the greatest damage found near the mouth of Wahoo Creek. This damage is estimated to be \$17,000 annually.

*Swamping.*—Swamping damage occurs mostly in the eastern third of the watershed. Each year an additional 57 acres of land are damaged an estimated 40 percent. This damage results from sediment deposits causing natural levees, the raising of water tables because of stream aggradation, and impairment of internal drainage



of flood-plain lands. It is estimated that the average annual damage by swamping is \$2,600.

*Transportation facilities.*—Transportation facilities, principally roads and railroads, are subject to damage by sediment. Since this damage is so closely associated with the damage to these installations which is caused by floodwaters, and since the basis for an estimate of the value of them is the annual maintenance cost, no separate evaluation has been made. The annual damage listed under inundation damage includes that caused by floodwater and sediment.

#### *Indirect damage*

The indirect damage considered in this report is the secondary effect of direct damage to nonagricultural installations and to agricultural property. The major part of indirect damage is that associated with nonagricultural damage. Among the most evident forms of this are interruption, dislocation, or breakdown of trade, transportation, and manufacturing and processing industries; costs of rescue and care of flood victims; cost of policing and sanitation; and disruption of educational programs.

Indirect damage to industry and trade is felt largely in employees' loss of wages, a loss of buying power; costs of evacuation and reentering; costs of salvage of goods, equipment, and facilities; and restoration and resumption of trade. Aftereffects are experienced in further spoilage of flood-damaged goods, price-depressing effects of forced sales, and in many other abnormal conditions of trade. Much of this indirect damage is measurable. Part of it, however, is an intangible loss to be estimated only in general terms.

Indirect damages resulting from interruptions of transportation facilities are not limited to losses to business and industry. Curtailment of incoming supplies and of outlets to markets affect the welfare of farm and city populations. Individual farms or groups of farms are temporarily isolated with consequent distress to inhabitants.

The indirect damages described above are usually associated with larger floods.

The indirect damage associated with agricultural direct damage includes many inconveniences and expenses such as those caused by damaged fences and farm roads. In some instances, livestock must be kept in corrals while fences are being repaired; and, in other instances, livestock escape from pastures before the damaged fences are discovered. Damage to farm roads have prevented ready access to fields and pastures. The damages discussed in this paragraph are experienced even during periods of minor flooding.

The average annual indirect damage in the Salt-Wahoo Creeks watershed is estimated to be \$128,300.

While not evaluated in monetary terms, the loss of human lives in past floods and the deprivation and hardship during and following a major flood are of great concern in this watershed. One of the most common and formidable pests of man and livestock in the Missouri Basin is the prodigious number of floodwater mosquitoes (*Aedes vexans*) produced as a result of floods.

In recognition of the hazards of probable flooding, owners of large areas of flood-plain land have not developed their property to the point of realizing the maximum possible return from their investments.



This item has not been evaluated as a flood damage, but the removal of the flood hazard through the application of a watershed program will make possible the development of these areas. This item is considered as an enhancement of property values, and is included in the discussion of benefits from the program in a later section of this report.

TABLE 4.—Average annual damage, Salt-Wahoo Creeks watershed

[Long-term projected prices]	
Type of damage	
Inundation damage:	
Agricultural:	Average annual damage
Crops and pastures.....	\$317, 500
Other agricultural.....	25, 200
Nonagricultural:	
Urban.....	123, 600
Roads.....	168, 400
Bridges.....	181, 500
Railroads.....	88, 600
Subtotal.....	904, 800
Land damage:	
Gully erosion.....	39, 000
Stream-bank erosion.....	4, 100
Flood-plain scour.....	2, 300
Subtotal.....	45, 400
Sediment damage:	
Deposition.....	17, 100
Swamping.....	2, 600
Subtotal.....	19, 700
Indirect damage.....	128, 300
Total.....	1, 098, 200

## CURRENT STATUS OF WORK

### ACTIVITIES RELATED TO THE APPLICATION OF LAND-TREATMENT MEASURES

Various Federal, State, and local agencies interested in the development of land and water resources in the watersheds are cooperating in the matter of providing landowners and operators with technical services, educational assistance, and direct aids in connection with fulfilling their responsibilities for conservation of the soil, forest, and water resources, and for increasing the productivity of the watershed lands.

The agencies of the Department of Agriculture are assisting individual farmers and groups of farmers in the application of measures for soil and water conservation, for improvement and maintenance of soil productivity, and for other activities related to land management. Soil-conservation districts have already been established in all the counties in the watershed.

In all counties in the watershed, assistance is given to farmers in carrying out practices designed to control erosion and maintain fertility of soil resources. Financial assistance is provided for the establishment of improved practices which have been given prior approval by local county committees.

At the present time, several agencies of the Department are active in forestry activities as a part of their over-all program. Under the Clarke-McNary program, trees are made available to farms throughout the area, most of which are used for windbreak and shelter belt plantings. Applicable types of planting and cultural practices are encouraged and incentive payments are made for tree planting and maintenance.

The Agricultural Extension Service has offices in every county in the watershed and is providing educational assistance to landowners and operators relative to the objectives and needs for the recommended program. Only a small part of the education work that will ultimately be required to create a realization of the need for the complete program has been done.

#### ACTIVITIES RELATED TO FLOOD CONTROL

The principal flood-control works which have been completed in the Salt-Wahoo Creeks watershed have been those affording local protection to towns and cities. The most comprehensive work is that which has been done through and downstream from the city of Lincoln on the main stem of Salt Creek and its tributaries in that vicinity. The work was started in 1891 subsequent to the formation of Sanitary District No. 1 of Lancaster County, and has been continued intermittently ever since with the result that, with the exception of a few short reaches, the channel straightening and relocation now extends from Lincoln to the mouth of Salt Creek. The city of Lincoln has also undertaken work of improving the flow conditions of Antelope Creek, a small tributary of Salt Creek which flows through the residential and business district of the city. This work consists of about one-half mile of closed masonry conduit, 20 feet wide and 10 feet high, and some realinement of the open channel. Throughout the watershed, individuals have attempted to relieve their flood problems by straightening the stream channels for short reaches, but there has been no coordinated plan of action on this work.

Following the disastrous flood of May 8-9, 1950, an organization of local people was formed for the purpose of sponsoring a complete program of water conservation, erosion control, flood abatement, and recreation. It is a voluntary, nonprofit, nonpartisan organization which was incorporated in July 1950 under the laws of the State of Nebraska and is known as the Salt-Wahoo Watershed Association. This group has been very active in promoting an investigation of the needs of the entire watershed. The Corps of Engineers was authorized to conduct a survey of the area by a resolution adopted by the Flood Control Committee of the House of Representatives on June 21, 1944. Since the Corps of Engineers received that authority, and particularly since 1948, they have made studies in this watershed. In July 1950 the Department of Agriculture was given similar authority by a resolution of the Public Works Committee of the House of Representatives and since then both agencies have conducted a joint study of the watershed.

The joint work involved the determination of the flood and erosion problems in the area, the hydraulic and hydrologic characteristics of the stream systems and the watershed lands, and the economic factors which influence the final determination of programs. Technicians of

the two agencies worked together on these common problems of basic data and there was a free exchange of information which the two groups had collected. These joint studies will be continued for the purpose of correlating the programs of the two agencies to the fullest extent possible prior to the initiation of construction of the structures or improvements involved.

#### CURRENT RATE OF PROGRESS

Much has already been done under the Department's current program to establish conservation measures on the lands of the watershed but a greater amount remains to be done. Conservation plans have been prepared for a total of 2,500 farms. Most of the farms in the watershed have one or more of the needed practices applied to at least a part of the land. However, at present rates of establishment, it is estimated that more than 50 years would be required to establish complete programs on all of the farms. Some of the practices such as contour farming, terracing, and outlets and waterways would be applied more rapidly if more technical assistance and conservation payments were available for planning and application on the land. With practices such as permanent grass seeding, seeding grasses and legumes in the rotation, pasture management, and the planting of woodlands, the lag is due partly to a need for a stepped-up educational program, as well as for additional technical assistance and financial aids.

#### ANNUAL EXPENDITURES UNDER CURRENT PROGRAMS

The Department of Agriculture is currently spending an estimated \$273,000 annually in the watershed to provide technical and educational assistance and conservation payments for those parts of the current program which contribute to the objectives of the total needed program. The major proportion of this expenditure is in the form of payments made to assist farmers in getting conservation established on their lands.

#### DESIRABLE PATTERN OF LAND USE

The installation of all phases of the land-treatment program and the attainment of the full benefit that can be expected to accrue therefrom, including the stabilization of the soil resource, increased agricultural production and reduction of flood and sediment damage, is based on land use in accordance with the capability of the land. The recommended land use is based on reconnaissance conservation surveys covering the entire watershed. Following the principle of keeping the land in the most intensive use for which it is suited, consistent with the maintenance of the soil resource, the recommended program includes the conversion of some cropland to pasture and woodland, and pasture to cropland and woodland.

The net effect of placing each acre of the agricultural land in the watershed in its proper use amounts to a reduction of about 13 percent in cropland, an increase of 44 percent in grassland, and an increase of 55 percent in woodland.

Crop rotations supported by terracing, contouring, and adequate water-disposal systems will be of major importance in reduction of



runoff and sediment production, inasmuch as about 68 percent of the agricultural land is recommended to be in cropland. The recommended crop rotations will effect an over-all decrease of 34 percent in acres of intertilled crops, a 3-percent decrease in acres of small grains, and a 22-percent increase in acres of rotation hay and pasture.

Present and planned use of the watershed land is shown in table 5.

TABLE 5.—*Land use, agricultural land, present and planned, Salt-Wahoo Creeks watershed*

[Percent]		
Use	Present	Planned
Intertilled crops.....	34.0	22.5
Small-grain crops.....	31.6	30.5
Legumes and grasses on cropland.....	<sup>1</sup> 12.1	14.7
Total cropland.....	77.7	67.7
Permanent grassland.....	20.9	<sup>2</sup> 30.1
Woodland.....	1.4	2.2
Total.....	100.0	100.0

<sup>1</sup> Much of this present acreage of legumes and grasses is not actually used in a proper rotation, or is on land that should be in permanent grass.

<sup>2</sup> Includes grass waterways and outlets.

### TOTAL NEEDED PROGRAM

The total needed program (table 7) is designed to preserve and protect the land, water, and forest resources of the watershed and to increase the productivity of watershed lands. This is to be done by furnishing technical assistance, information, and other aids to individual farmers and groups of farmers in the application of recommended measures; helping groups of farmers to organize for the installation of effective land- and water-management programs; and providing for an equitable sharing of costs between the individual landowner and the public in order to help insure establishment of the complete program during the period designated for installation.

The program herein recommended includes the intensification, acceleration, and adaptation of certain activities under current programs of the Department and additional measures not now regularly carried out in such programs, all of which are necessary to increase agricultural production and to complete a balanced runoff and water-flow retardation and erosion-control program for the watershed. It also provides for the effective integration and coordination of these programs and activities. The current activities of the Department of Agriculture in the watershed were considered in light of the total needs of the area.

The estimated quantity of measures needed, the installation costs of the measures, and the apportionment of costs of the total needed program are shown in table 7. The installation cost shown for each measure includes the cost of direct aids necessary to accelerate the program. The share of the costs to be borne by the land operators, as set out in the tables, includes their out-of-pocket expense plus the estimated value of labor expended; machinery operating costs, including depreciation; and other miscellaneous expenses. The costs of technical assistance, extension education, and the administrative

costs of direct aids required to establish the program in the time specified are shown in lump sums apportioned between Federal and non-Federal agencies.

#### CONSERVATION AND IMPROVEMENT MEASURES FOR CROPLAND, PASTURELAND, AND WOODLAND

The measures needed on cropland and pastureland are aimed at increasing production consistent with conservation of soil resources, and will contribute directly to reduction of erosion and control of runoff. Improved agronomic practices, including soil-conserving rotations, management of crop residues, improvement of pastures, and increased use of fertilizer and lime where needed, are provided for. Supporting practices such as terracing, contouring, and establishment and stabilization of small farm waterways and terrace outlets are included.

Application of the measures will be accelerated by extension education, providing technical services, and providing incentive payments, materials, and other services.

The kinds of measures required for the conservation and improvement of cropland, pastureland, and woodland are described in detail below.

##### SEEDING GRASSES AND LEGUMES

Initial seedings of 134,500 acres of grasses and legumes are needed on cropland to establish crop rotations adapted to the capability of the land. The crop rotations are basic in the conditioning of cropland for runoff and erosion control, and increased production. These rotations will include, in general, legume and grass mixtures used for hay production or pasture, and annual or biennial legumes used principally as green-manure crops. Legume and grass species to be used will be those able to produce abundant root growth to provide the maximum effect on runoff and sediment production and on soil productivity. The establishment of recommended crop rotations will require adequate lime and fertilizers, which are included in the program.

##### CONTOUR-FARMING PRACTICES

There are 578,000 acres of cropland in the watershed on which farm operations should be carried out on the contour. This includes all land to be terraced, as well as other sloping cropland not requiring or not suited to terracing. On some fields, this contouring will be done in a strip-crop pattern. This measure will permit more intensive use of cropland without land deterioration than would otherwise be possible, and have a favorable effect on crop yields due to increased moisture penetration and more uniform crop stands.

##### TERRACES

Approximately 34,800 miles of terraces are needed on cropland which has sufficiently long or steep slopes to produce damaging concentrations and velocities of runoff, and where adequate control cannot be achieved through vegetative practices or less intensive mechanical methods. Graded terraces will be used to conduct the surplus water at nonerosive speeds to the stabilized outlets and waterways provided

for in the total needed program. In some fields, diversions will be required for interception and safe disposal of runoff from pastures above. Farm operations on terraced land are to be performed on the contour, and terrace systems will be designed in such a manner as to facilitate contour operations.

#### CROP RESIDUE MANAGEMENT

The use of straw and stubble residues to give erosion protection to 283,700 acres is needed. This measure requires tillage operations that will retain a large part of the straw and stubble at the surface where these residues help dissipate the force of raindrops, reduce splash erosion, and allow water to enter the soil more rapidly. This measure is also important in helping to control wind erosion which, although seldom serious in the watershed, must be guarded against.

#### SEEDING PASTURES

The establishment of 196,000 acres of adapted varieties of grasses is needed on land to be converted to pasture and on land where stands have been depleted or denuded. This acreage includes areas where natural methods are incapable of restoring suitable vegetation. Fertilizer will be needed for rapid establishment of vigorous stands, particularly on eroded land previously cropped.

#### PASTURE MANAGEMENT

Improved methods of management on 252,000 acres of pasture land will increase production and reduce runoff and erosion. The management methods involve adjustment of livestock numbers to give the grass a better chance to grow and, where a substantial proportion of the desirable forage plants is still present, to improve the stand by natural reproduction. In addition to adjustment of livestock numbers, pasture management will require attention to proper season of use, and in some cases will require rotation grazing and deferred grazing. Pasture-management programs will be worked out farm by farm, as a part of the conservation program.

#### PASTURE CLEARING

This measure should be accomplished on approximately 5,600 acres where brushy plants have taken the place of the natural vegetation. Removal of these plants will allow the desirable grasses to become re-established and enable the pastures to return to their normal productive capacity. Removal of these plants will be accomplished principally by mowing, spraying, or dozing.

#### LIVESTOCK WATERING FACILITIES

Thirteen hundred livestock watering facilities need to be developed to provide adequate water for livestock to permit proper distribution of grazing and allow productive use of all pasture lands. These facilities may be stock ponds, wells, or, in some cases, spring developments.



## CONTOUR FURROWS OR PITTING

Contour furrowing or pitting should be installed on approximately 130,500 acres of pasture land. This measure is needed to increase grass production and decrease runoff from pastures.

## LIMING AND FERTILIZING

The application of lime on approximately 110,000 acres and fertilizer on approximately 341,000 acres are needed to obtain proper land use and successful application of soil-conservation measures. Only recently have these needs become evident, but tests of some fields are showing that lime should be applied for proper growth of legumes in the rotation. The need for fertilizers in establishing the rotation is more widespread. In most cases fertilizer will also be needed for the establishment of vigorous stands of grasses and legumes on present eroded cropland to be converted to pasture.

## OUTLETS AND WATERWAYS

Approximately 4,200 miles of small grassed waterways are needed to provide for the disposition of surplus water at nonerosive velocities into the subwatershed waterways. Natural waterways will be reshaped, gullies will be filled, and suitable mixtures of sod-forming grasses and adapted legumes will be established. Where fields are terraced, constructed outlets other than natural waterways may be needed in some cases. Fertilizer and barnyard manure will be needed for the establishment of vigorous stands in most cases, and lime should be applied where tests show the need. As a general rule, hay will be harvested from these areas to prevent smothering of the sod by heavy growth. It will be necessary to give careful attention to the maintenance of vigorous stands once they are established.

## EROSION-CONTROL STRUCTURES

Approximately 1,160 small erosion-control structures are needed to stabilize terrace outlets and small vegetated waterways. The structures will include concrete, rubble masonry, and earth dams with draw-down tubes, chutes, or flumes.

## DIVERSIONS

Approximately 760 miles of diversions should be constructed to direct concentrated runoff from above fields and eroded areas in pastures and conduct it to safe disposal in stabilized waterways. In most cases, the channels and side slopes of diversions will be kept in permanent vegetation.

## FENCING

Approximately 450 miles of fences are needed for control and distribution of livestock. These will be new fences which are needed for carrying out proper pasture management.

## WOODLANDS

Following is a description of forestry measures recommended for installation in the watershed to meet conservation, water-flow retardation, and erosion-prevention needs.

## FARM WOOD LOT AND SPECIAL FARM PLANTINGS

The establishment of about 10,000 acres of woodlands is recommended on areas too steep for cultivation, on odd areas along streams that are now idle, and in small openings in existing stands. These plantings will check and prevent gully erosion now prevalent in the area, reduce bank cutting along the main waterways, increase infiltration rates, and reduce runoff. They will yield quantities of wood products such as lumber, posts, Christmas trees, poles, and fuel wood, and improve wildlife habitat. The newly planted areas will be protected from grazing by the construction of necessary fences.

## WINDBREAKS AND SHELTER BELTS

The establishment of windbreak plantings on about 5,300 acres is recommended to protect farmsteads and livestock from wind and drifting snow. While many farmsteads have limited protection of this type, many need extending or reinforcing; others are in need of complete protection.

Field shelter belt plantings are recommended on about 500 acres in the western portion of the watershed. These plantings will prevent desiccation of crops and loss of soil moisture from drying winds, stop drifting snow, reduce wind erosion, provide wildlife habitat, and produce wood and other products.

## WILDLIFE HABITAT IMPROVEMENT

To improve the environment for wildlife in the watershed, the establishment of about 1,050 acres of wildlife plantings is recommended. These plantings will largely be on odd upland areas unsuitable for other types of use, but also include the interplanting of shrubs on existing woodlands where other conditions are favorable.

## INTERPLANTINGS

Due to overcutting, poor cutting practices, and grazing, existing woodlands are producing but minor quantities of low-value products. To improve the quality and quantity of future products and to hasten proper site utilization, the underplanting of about 1,800 acres to more valuable species is recommended. These plantings will be made in combination with the timber-stand improvement work recommended.

## TIMBER-STAND IMPROVEMENT

Many of the existing woodlands are composed of poorly formed and low-value species or contain limited amounts of valuable species such as black walnut. Some of the more recent plantings are in need of pruning, thinning, or other treatment. In order to improve the com-

position, quality, and growth rate per acre of these stands, funds for the removal of weed trees, release cuttings, pruning, thinning, and other silvicultural treatment are provided for about 5,200 acres of such work.

#### IRRIGATION

Irrigation development in the Salt-Wahoo Creek Basin is now limited to a few farms where supplemental water is supplied to small acreages from ground aquifers during the critical growing season in dry years. Approximately 1,300 acres are now irrigated. The estimated ground water supply for irrigation is adequate for supplying from 6 to 12 inches of supplemental water for a minimum of 25,000 acres in the watershed. In most years crops are in need of from 7 to 10 inches of additional moisture. Installation of this production increase practice will be carried out by interested farm operators under private initiative and expense except for technical assistance and land preparation payments. It is anticipated that the needs for installation of this practice will be met under the current program.

#### DRAINAGE

Lands along the Salt Creek Valley and in the area known as the Todd Valley in the Wahoo Creek drainage area are in need of drainage in most years, particularly following periods of heavy rainfall. A few small areas are consistently too wet for maximum crop production. It is estimated that 20,000 acres are in need of drainage in the Salt-Wahoo Creeks watershed and are included in this watershed program.

#### TECHNICAL ASSISTANCE

The amount and cost of technical assistance required to inventory soil and water resources and land capability for maximum economic production; to prepare farm plans; to prepare work plans for installations; and to provide technical advice and counsel necessary to apply the land-treatment measures have been calculated as a part of the installation cost of the total program.

#### EDUCATIONAL ASSISTANCE

The Agricultural Extension Service has offices in every county in the watershed and is providing educational assistance to landowners and operators relative to land- and water-resource use, conservation, and development. In order to accelerate the application of needed work on the land, however, there will need to be more intensive effort expended in educational work than is now possible with existing staff and material resources available. The program recommends an increase in funds to provide for these facilities.

#### ADMINISTRATION OF DIRECT AIDS

An increase in the rate of applying conservation measures will require some increase in funds necessary to administer direct aids. An estimate of the total administration cost of direct aids is calculated and included as a part of the total cost.



## MEASURES FOR STABILIZING SMALL WATERCOURSES

The improvements for the stabilization of small watercourses consist of measures some of which are interrelated and interdependent and should be installed concurrently on minor watersheds. The proper combination and sequence of installing these measures with land use and conservation practices will attain most effectively and economically the objective of soil and water conservation, an increase in agricultural production, and the reduction of land, floodwater, and sediment damages. The program as a whole will increase the intake of water into the soil, retard runoff of water that is not absorbed, and conduct the runoff along its least damaging route to the larger drainage ways.

The land-treatment program for the watershed is designed to develop a favorable condition for infiltration, water storage, and yield of agricultural products. This favorable soil condition will retard a maximum amount of the rainfall consistent with the use of land for productive purposes, and will reduce the rate at which runoff will reach the waterways and tributary streams. On the other hand, it is recognized that the intensity of many rains will exceed infiltration capacities of the soils of the watershed and that runoff of flood-forming proportions will occur even under the most favorable conditions of land use and treatment. It is this excess runoff which must be conducted to the main streams in an orderly manner if erosion damage is to be reduced and downstream inundation and sediment damages abated. Stabilizing measures for small watercourses are needed, therefore, to temporarily retard the damaging runoff and to provide the necessary control of water so that it will pass through the minor waterways and tributary channels with a minimum of damage.

The measures for stabilizing small watercourses have these characteristics:

Their primary purpose is to stabilize minor waterways and tributary streams and to provide for orderly water disposal and sediment control as an essential part of a complete and integrated program of runoff and water-flow retardation and soil erosion prevention. These stabilizing measures reduce flood and sediment damages, maintain land resources, and protect water-resource developments in the watershed against impairment by sedimentation.

They frequently involve groups of landowners and operators with common interests in protecting minor watershed units, as well as local agencies of government.

They justify substantial public expenditures in technical and other assistance.

A discussion of the kinds and amounts of measures for stabilizing small watercourses in the Salt-Wahoo Creeks watershed follows:

## UPSTREAM FLOODWATER RETARDING STRUCTURES

An estimated 165 structures for floodwater retarding purposes are required. These measures, by providing temporary storage, will reduce flood damages caused by runoff in excess of that which can be controlled by the land-use and conservation practices. In addition, installation of these structures will permit more intensive agricultural use of bottom lands. Areas of land now idle or used for pasture because of flood hazards may be utilized for crop production.

Some of these structures will have the added feature of grade stabilization incorporated in the design. This will permit the installation of the complete land-treatment program above sites where grade stabilization is required for efficient and continued effectiveness of the land-treatment measures.

The structures are at sites where the temporary impoundment of water will result in a minor loss in the agricultural production of the land in the reservoir area. The principal type of structure is a small earth-fill dam with an outlet to release water at a fixed and safe rate, and a spillway adapted to site conditions. The structures are planned to temporarily store  $3\frac{1}{2}$  inches of runoff without spillway discharge. Drainage areas above the structures range from less than one-half to about 6 square miles.

#### CHANNEL IMPROVEMENT

Approximately 142 miles of small stream-channel improvement works are required. The improvement works will consist of the removal of obstructions, the stabilizing of banks by vegetation, the reshaping and realinement of channels, and the installation of small structures adaptable to the conditions encountered.

Channel improvement is needed in many parts of the watershed to reduce land damage by stream-bank erosion, to reduce damage from sedimentation, and to increase channel efficiency. The channel improvement works are generally limited to control measures on streams draining less than 25 square miles. Such works will be installed at locations providing protection for cropland, highways, railroads, bridges, utilities, farm buildings, and other high-value improvements.

#### STABILIZING AND SEDIMENT-CONTROL STRUCTURES

An estimated 2,376 structures of this type will be required for the control of overfall, head-cutting gullies, and the stabilization of gradients in upstream channels. The objective is the stabilization of subwatershed drainage ways, including road ditches and other artificial channels. The principal types of structures to be installed are drop inlets, chutes, culverts, weir drops, and small retention dams (water-flow control structures). Some of these structures will be adaptations of present road culverts. The structures should be installed in proper sequence and combination with the land-treatment measures. Generally, only a part of the benefit of these structures will accrue to the owner of the land on which they are installed. Therefore, their installation and maintenance will usually involve participation of a group of owners.

#### SUBWATERSHED WATERWAY IMPROVEMENT

Approximately 968 miles of subwatershed waterway improvement will be needed to stabilize and protect natural and artificial channels. These measures include establishment and maintenance of grasses in upland drainage ways and artificial channels such as floodways. These waterways generally provide water disposal for a group of farms. The improvements consist of excavating, shaping, preparing, and seeding the waterways. Structures needed in conjunction with the vegetative control are included with the stabilizing and sediment-control structures.



## RESEARCH

In the Salt-Wahoo watershed, program evaluation and study of soil and water conservation effects resulting from changes in land use, application of various combinations of conservation treatment, water runoff and sediment control structures will be a vitally important phase of the watershed improvement program. Hydrological and sediment movement data obtained progressively as the program is applied over the entire watershed in the course of a period of 10 years will be invaluable to the sciences of hydrology, sedimentology, and engineering design where such data may be systematically obtained through properly designed and adequately installed instrumentation covering an area embracing an entire watershed within the size range of economic feasibility for prosecuting such evaluations.

These technical and economic evaluations will not only serve the needs and interests of the local individuals and interested agencies within the watershed, but will also serve the interests of contiguous and many other comparable watersheds throughout the Missouri River Basin and other river basins in the Middle West.

These studies and evaluations will be conducted cooperatively by the Nebraska Agricultural Experiment Station, the United States Department of Agriculture, the United States Geological Survey, and the United States Weather Bureau.

## CONSERVATION AND MANAGEMENT OF FARM LANDS

*Management and conservation of soil and water*

There is an appreciable loss of soil and water from the sloping uplands in the area during heavy rains. That loss of soil and water is accentuated by a low permeability of the soil and by a large proportion of the land in corn and small grains. An increase in the proportion of grasses and legumes in the area will reduce soil and water losses. Information is needed on the proportion of legumes and grasses in the cropping system necessary for effective control of soil and water losses. It will be necessary to determine the best soil treatment to obtain adequate stands and production of grasses and legumes on different soils of the area. Cultural and tillage practices will need to be evaluated for certain soils in the watershed.

*Economic research*

The success of conservation and flood-control projects depends largely on the participation of the individual farmers in the district. Farmers need to know the costs and benefits of recommended practices. Other problems of farmers are related to rental arrangements, tax procedure, and credit arrangement. Recommended research includes a study of the cost and benefits of a complete conservation program, an analysis of obstacles to conservation, a study of rental arrangements that will encourage conservation, and a study of credit needs and sources of credit. The Salt-Wahoo Watershed Association is sponsoring a conservancy district enabling act. Information is needed on which to base the operation of this local district.

## FOREST RESEARCH

In the Plains areas, trees and shrubs are needed to conserve moisture, to protect lands from floods and stream banks from erosion, to



shelter farmsteads and crops from sun and wind, and to shield roads from drifting snow. Trees are also needed to supply wood products for local markets. Most of the merchantable trees in the farm wood lots have been cut and in their place have grown inferior and less valuable timber cover. Because very little attention has been given to the forestry problems of this watershed, a program of research is needed to point the way to more profitable and efficient use and management of the shelter belts and farm wood lots. The results of this research will be applicable to a considerable area in the Nebraska and Kansas portions of the Missouri River Basin. Therefore more intensive effort is justified than if the results were applicable only to the Salt-Wahoo watershed. As an additional feature, research plans for this area have been coordinated with those for the Blue River watershed in Nebraska and Kansas, which occupies land with generally similar characteristics.

#### *Forest economics*

Forest economic data are needed in evaluating contributions of the recommended forestry measures to the agricultural and industrial economy of the watershed. A comprehensive inventory of farm and wood lots, windbreaks, and shelter belts, and potential planting sites on the farms is necessary to determine the potential development of timbered areas for wood products.

### REDUCTION OF WATER RUNOFF AND SEDIMENT PRODUCTION

#### *Effect of land use on runoff and erosion*

There is an increasing need for a better understanding of the effects of land use and conservation measures upon the rate and amount of runoff from watersheds. A great deal of information has been obtained from plot experiments which emphasizes the seriousness of the losses of both soil and water from agricultural lands. Such data from plots and small-area experiments indicate the general effects of land use and applied conservation practices on erosion and runoff from similar small areas. Along with other data, they provide the necessary basis for estimating runoff from larger areas. They are not, however, a measure of the performance of natural watersheds and drainage units such as those to be encountered in application of the recommended program in the Salt-Wahoo and other generally similar watersheds in the eastern part of the Missouri River Basin. Thus far, there has not been an opportunity in this country to measure directly and study the effects of land use, conservation measures, and other watershed treatments upon the rainfall-runoff relationships of a relatively very large natural watershed.

Direct measurement of the rainfall-runoff relationships for a large natural watershed and its smaller component drainage units is necessary to further advancement in development of techniques for obtaining reductions in flood damages, water conservation, and associated benefits by means of conservation measures and related small, upstream engineering works. It is proposed that the Salt-Wahoo area will be used for such a study. This watershed is rather ideally located for such purposes. It is near the Hastings research watershed and studies in the two areas will be used to supplement each other. A backlog of hydrologic data has already been collected at the Hastings Station for watersheds ranging in size from 4 to about 3,500 acres.

The detailed information and conclusions developed for small watersheds in that area can be extrapolated to conditions in the Salt-Wahoo with a minimum of adjustment and will greatly facilitate the study. Soil, climatic, and agricultural conditions found in the Salt-Wahoo area are generally representative of extensive portions of Nebraska, Kansas, Iowa, Missouri, and southeastern South Dakota. Consequently, observations and conclusions based on study in the area would be widely applicable throughout the Missouri River Basin.

The objective of the investigations shall be to study the rainfall-runoff relationships for the entire Salt-Wahoo area with the program in effect and to compare these with conditions that would prevail without the benefit of proper land use, conservation measures, and other related improvements in the watershed. By means of water-stage recorders, a continuous record of the rates and amounts of runoff will be maintained for selected drainage areas. A network of automatic and standard rain gages will be established over the area to provide information on the rates and amounts of precipitation. A continuing inventory of land use and the kind and amount of conservation practices by soil groups will be maintained. Selected runoff events will be analyzed to determine the effects of rainfall, land use, and related factors on observed rates, amounts, and stages of stream flow. Studies will be made of the gains and losses in water after it has left the upland fields and entered the channel system. The influences of flood-detention reservoirs on stream discharge will be observed with the view of improving techniques for flood routing. Information will be developed for observing the relationships between rates and amounts of runoff and size of watershed.

#### *Control of reservoir silting*

The need and justification for data on the effects of land use and conservation measures upon sediment production of watersheds is much the same and closely parallels that of water runoff and stream flow. The relative amounts of erosion on and soil lost from plots and small areas under various uses of land and under different conservation treatments is fairly well established. It is also well known that performances on plots and small areas with respect to erosion and sediment production are not the same as on natural watersheds. As in the case of runoff, there is a particular need for study of the effects of land use, conservation measures, and other watershed treatments, including shrub and tree planting, upon rates of sediment production of a large natural watershed.

Sediment production is a critical consequence of floods and erosion in most watersheds. Silting is a major problem in planning and maintaining storage and detention reservoirs in many parts of the Missouri River Basin. Existing data indicate that many sediment problems can be significantly reduced by proper land use and the application of required conservation measures. In no case has it been possible thus far, however, to measure the effects of complete conservation treatment of a large natural watershed upon sediment production. More information on a watershed basis is urgently needed for use in developing better procedures and measures for controlling sediment. For a number of reasons the Salt-Wahoo area is well suited for a study of the relation of sediment production to soils, climate, land use, farming practices, conservation measures, and related causal factors.



It is proposed that the recommended sedimentation studies will be conducted in close coordination with runoff investigations in the area. Sediment-load measurements will be taken at each of the stream-flow stations by standard suspended-load sampling techniques. The silt-sampling program will be carried out in the detail necessary to provide a well-defined hydrograph of sediment discharge of each runoff event at the stations. In addition, rates of sediment accumulation will be measured in selected flood-detention reservoirs for additional information on rates of sediment production from smaller drainage area sizes.

The accumulated rainfall and runoff data, information on land use and conservation treatments, and the records of sediment production will be analyzed to determine the relative importance of factors responsible for sediment production. Changes in the sediment load carried by the streams will be measured. The effects of land use and applied conservation practices in reducing sediment production of the area will be determined through analysis of the data collected.

*Evaluation of benefits from reduction in water runoff and sediment*

An economic analysis needs to be made of practices and measures suggested for controlling runoff, siltation, and sediment transportation.

Enormous economic values have been built up in certain flood-plain lands. Consequently, severe floods result in heavy economic losses. Hence, there is a need to study the relationship between use of flood-plains and flood damage and the economic benefits of various approaches to reduction of flood damage, including direction of economic development in certain parts of the flood plains. The question of zoning flood-plain land should be given careful study.

## SOIL SURVEYS AND LAND CLASSIFICATION

Recent basic soil surveys are available for all but a few thousand acres of the watershed. No new surveys of this type are recommended.

TABLE 6.—*Estimated Federal cost of research, Salt-Wahoo watershed (10-year program)*

<i>Type of research</i>	<i>Total cost of recommended programs</i>
Conservation and management of farm lands:	
Soil and water management.....	\$160, 000
Economic research.....	100, 000
Subtotal.....	260, 000
Forest research: Forest economics.....	40, 000
Subtotal.....	<sup>1</sup> 40, 000
Reduction of water runoff and sediment:	
Effect of watershed treatment on runoff.....	<sup>1</sup> 390, 000
Control of reservoir silting.....	<sup>2</sup> 576, 600
Evaluation of benefits.....	80, 000
Subtotal.....	1, 046, 600
Total.....	<sup>3</sup> 1, 346, 600

<sup>1</sup> Includes \$24,500 for costs of installation.

<sup>2</sup> Includes \$27,800 for costs of installation.

<sup>3</sup> The Nebraska Agricultural Experiment Station expects to provide approximately \$200,000 additional for cooperative research on these items.



TABLE 7.—Total needed program, Salt-Wahoo Creeks watershed

[Long-term projected prices]

Measures	Unit	Quantity	Installation costs			
			Federal	Non-Federal public	Private	Total
Conservation and improvement measures:						
Crop and grasslands:						
Seeding grasses and legumes	Acre	134, 500	\$726, 300		\$887, 700	\$1, 614, 000
Crop residue management	do	283, 700			141, 800	141, 800
Contour farming practices	do	578, 000				
Terraces	Mile	34, 800	2, 610, 000		2, 610, 000	5, 220, 000
Seeding of pastures	Acre	196, 000	1, 058, 400		1, 293, 600	2, 352, 000
Pasture management	do	252, 000				
Pasture clearing	do	5, 600			140, 000	140, 000
Livestock watering facilities	Number	1, 300	286, 000		234, 000	520, 000
Contour furrowing or pitting	Acre	130, 500	130, 500		391, 500	522, 000
Lime	do	110, 000	363, 000		297, 000	660, 000
Fertilizer	do	341, 000	852, 500		852, 500	1, 705, 000
Outlets and waterways	Mile	4, 200	1, 134, 000		756, 000	1, 890, 000
Erosion-control structures	Number	1, 160	817, 300		668, 700	1, 486, 000
Diversions	Mile	760	148, 200		79, 800	228, 000
Fencing	do	450			202, 500	202, 500
Irrigation	Acre	25, 000	250, 000		1, 000, 000	1, 250, 000
Drainage	do	20, 000	120, 000		800, 000	920, 000
Farm wood lots—shelter belts:						
Farm wood lot and special farm plantings	do	10, 000	151, 300	60, 500	393, 500	605, 300
Windbreaks and shelter belts	do	5, 800	180, 300	72, 100	468, 900	721, 300
Wildlife habitat improvement	do	1, 000	11, 700	81, 900	23, 400	117, 000
Interplantings—wood lots	do	1, 800	18, 100	7, 300	47, 100	72, 500
Timber-stand improvement	do	5, 200	8, 200		32, 900	41, 100
Technical assistance			2, 732, 500	103, 300		2, 835, 800
Educational assistance			180, 000	40, 000		220, 000
Administration of direct aids			781, 300			781, 300
Research			1, 346, 600			1, 346, 600
Measures for stabilizing small water courses:						
Upstream floodwater-retarding reservoirs	Number	165	2, 211, 200	105, 000	140, 600	2, 456, 800
Tributary channel improvement	Mile	142	162, 500	57, 900	11, 800	232, 200
Stabilizing and sediment-control structures	Number	2, 376	3, 012, 100	514, 300	238, 700	3, 765, 100
Subwatershed waterway improvement	Mile	968	821, 200	460, 600	86, 800	1, 368, 600
Total			20, 113, 200	1, 502, 900	11, 798, 800	33, 414, 900

## PROGRAM APPRAISAL

The various interrelated phases of work needed in the Salt-Wahoo watershed are set forth in table 7 and described in preceding pages. It is recommended that all of this work be carried out in proper combination and sequence over a 10-year period.

A portion of this work is already being carried out by authorized programs in cooperation with landowners and operators and other cooperating agencies. It is assumed that current programs will continue at near their present rate. This will not be sufficient, however, to carry out the work set forth in the total needed program.

An acceleration of certain phases of work and the addition of some phases of work not now being done will be required. The amounts, kinds, and costs of work, in addition to that which will be done during the 10-year period by the current program, are set forth in table 8, recommended accelerated program.

Economic evaluation is limited in this report to that part of the recommended accelerated program relating to water-flow retardation and prevention of soil erosion which are applied on watershed lands

in aid of flood control. Proportionate benefits are expected from application of the total needed program.

#### INCREASED CROPLAND, PASTURE, AND WOODLAND PRODUCTION

With installation of the recommended accelerated program, benefits will accrue from increased agricultural production and from increased infiltration and stabilization of the soil mantle, resulting in decreased runoff and sedimentation. In the upland areas, gully erosion will be reduced, while on the flood plains bank cutting will be alleviated, and scour and deposition decreased.

##### *Cropland*

The installation of the measures recommended for cropland will increase the total production of all major crops. Based on gross value at long-time expected prices, grain crops will be increased by approximately 22 percent, and hay and forage sorghums by 100 percent.

Even though a smaller acreage will be devoted to cropland under the recommended program, increases in per acre yields will result in greater production.

These increases in yields will be due to improved crop rotations, terracing with contour cultivation, and conversions to other uses of cropland not suited to cropping.

Only those amounts of lime and fertilizer have been included which are needed to establish the proper amounts of legumes and grasses in the rotation; hence, their effect on the production of grain crops will be indirect. The legumes and grasses in the rotations will increase the yields through the addition of organic matter and nitrogen, improved soil structure, tilth, aeration, and drainage. The combined effect of the measures recommended for cropland will increase per acre yields of corn about 11 bushels, wheat 5 bushels, oats 6 bushels, and hay 0.5 ton.

##### *Pasture*

The measures recommended for pastures are designed to attain a practical maximum yield from all the pasture acreage. The forage yield in terms of animal-unit months of grazing will be increased by about 80 percent. This gross increase in production will be brought about by both an increase in the acreage of land devoted to pasture, and an increase in forage yield per acre. The increased per acre yields will be the result of reseeding depleted stands, ridding pastures of competitive plants, providing additional livestock watering facilities, contour furrowing or pitting some areas, and the application of the recommended pasture-management practices. Much of the pasture land is now producing very low yields. Installation of the recommended program will increase total forage production by about 84 percent.

It is expected that livestock production will be expanded greatly as the program develops. No doubt roughage-consuming livestock will be increased to a greater extent than grain-consuming livestock, as the increase in pasture and hay production will be greater than the increase in grain production.

##### *Woodland*

The program contemplates the establishment of about 16,900 acres of wood lot, windbreak, shelter belt, and wildlife plantings. It also

provides for improvement measures on about 5,200 acres of present woodlands. Included in the program are funds for grazing control, technical services, and educational assistance to aid in the successful installation of the measures.

With installation of the proposed measures, benefits will be realized from reduced runoff and erosion and also many other benefits from increased productivity of the lands treated. Most of these benefits will accrue from lands presently idle or producing far below their potential capacities.

Of the 10,000 acres of farm wood lot and special farm plantings, 7,000 acres are expected to produce 7,500 board feet of saw timber per acre by the fortieth year following planting, leaving a reserve stand with an increment growth of 150 board feet annually. On 2,000 acres of special plantings, a yield of 600 posts per acre is expected by the end of the eighth year, after which continuous production can be attained by using coppice methods. On 1,000 acres of coniferous plantings, a yield of 1,000 Christmas trees per acre is expected by the end of the twelfth year, leaving a reserve stand for future cuttings of poles, posts, and saw timber. The interplanting of about 1,800 acres and stand-improvement work on 5,200 acres will produce additional amounts of the same products.

Windbreaks and shelterbelts will produce small amounts of the same wood products as the other plantings but benefits will largely result from protection of farmsteads, livestock and feed lots from the cold winter winds, reductions in wind erosion, and losses of soil moisture and the protection of crops from the hot summer winds. Road maintenance costs will be reduced by the establishment of permanent living snow fence and by reduced snow-removal costs. Farmsteads and lands protected from the hot summer and cold winter winds offer better places to live and this, together with the other benefits, is reflected in the sales value of such property.

#### EFFECT OF PROGRAM ON FLOOD DAMAGE

The reduction of damage to land and the reduction of inundation and sediment damage in the watershed depends upon the proper integration and the timeliness of installation of practices and measures recommended in this report. The land-treatment phase of the program is formulated to develop the most favorable conditions for infiltration and water storage. This favorable soil condition will permit maximum retention of rainfall and will reduce the rate at which runoff will reach the waterways and tributary streams. The flow of water which is not absorbed will be collected and conducted off the land through stabilized waterways to the larger drainage ways with a minimum of damage. Where practicable, upstream floodwater-detention structures will further retard the flow of water which is not retained on the land. Other measures such as floodways will reduce damages from bank erosion and scour of flood plains where existing channel capacity is not adequate to handle damaging flows.

Evaluation of the effects of the program indicates that land damages will be reduced by 82 percent, inundation damages by 56 percent, and sediment damages by 80 percent.



## OTHER BENEFITS

A principal objective of the program as a whole is the conservation and improvement in productivity of the land resources of the watershed. An additional benefit to be realized from the program of upstream retarding structures is the change in land use which will be brought about immediately below some sites. The net return from approximately 1,300 acres of the lowest income-producing land in the watershed will be increased by an estimated \$33,700 annually.

## ECONOMIC JUSTIFICATION

Economic justification in terms of benefit-cost ratio is included for those measures in the recommended accelerated program that contribute to water-flow retardation and prevention of soil erosion.

Benefit-cost ratio for land treatment measures installed primarily in aid of flood prevention are calculated separately from measures for stabilizing small watercourses. The program can be applied successfully on the land only if all parts of it are authorized and implemented to be carried out as one project in proper sequence and in proper proportions on each farm and each subwatershed. Annual work plans will be prepared for this purpose.

*Costs and benefits from land treatment measures*

It is estimated that the installation and maintenance of land treatment measures that contribute to waterflow retardation and soil erosion prevention will result in the following average annual benefits:

Conservation benefit or increased production of cropland, pasture, and woodland.....		\$6, 800, 000
Reduction in land damage.....	\$26, 500	
Reduction in inundation damage.....	258, 600	
Reduction in sediment damage.....	14, 600	
Reduction in indirect damage.....	36, 100	
		<hr/> 335, 800
Total average annual benefits.....		7, 135, 800

The annual operation and maintenance cost is \$1,292,400, all of which is borne by non-Federal funds. The average annual value of the total cost of these measures is \$1,817,200.

The ratio of benefits to cost is 3.9 to 1.

The average annual equivalent of the installation costs is computed by use of a 2½ percent interest rate for Federal and non-Federal public installation costs and a 4 percent interest rate for private installation costs. This annual equivalent plus the operation and maintenance costs result in the total average annual cost.

*Costs and benefits of measures for stabilizing small watercourses*

The upstream floodwater-retarding structures to be installed in the headwaters of tributary streams are designed to provide temporary storage for runoff. They will reduce both agricultural and nonagricultural damages from inundation and will protect flood-plain lands immediately downstream from the site to the extent that they may be put to a more intensive use.

The construction of stabilizing and sediment-control structures in conjunction with the improvement of subwatershed waterways will reduce erosion damage from gullies, reduce the depreciation of watershed lands which accompanies gully erosion in small watersheds, reduce sediment damage, and insure the continued effectiveness of the upland treatment measures. Since many of the needed upland measures are dependent on the above measures for permanent effectiveness, there is a conservation benefit attributable to the subwatershed waterway stabilizing program.

The construction of floodways in minor drainage ways and improvement of small-stream channels by stabilizing the banks, removing obstructions, and installing other protective measures will bring about a reduction in inundation, stream-bank erosion damage, flood plain scour damage, sediment damage, road and bridge damage.

The estimated costs, and distribution of costs, of installing and maintaining the measures recommended for stabilizing small watercourses are summarized in table 8.

The recommended measures installed on land not under the jurisdiction of the Federal Government are to be operated and maintained by State and local agencies under arrangements acceptable to the Secretary of Agriculture, and installation in any area will not be commenced until such arrangements have been made. The boundaries of any such area shall be determined by the Secretary.

The average annual cost of the stabilizing program includes the annual equivalent of the installation cost, operations and maintenance cost, and the cost of replacement where applicable. This annual cost is \$455,900. Of this, \$252,900 is operations and maintenance cost, and the cost of replacement where applicable, and will be borne by non-Federal funds.

It is estimated that the installation and maintenance of these measures will result in the following average annual benefits:

Reduction in land damage.....	\$10, 900
Reduction in damage due to inundation.....	248, 700
Reduction in sediment damage.....	1, 200
Reduction in indirect damage.....	39, 600
Conservation benefit.....	677, 900
Land enhancement.....	33, 700

Total average annual benefit.....	1, 012, 000
-----------------------------------	-------------

The ratio of benefit to cost is 2.2 to 1.

### RECOMMENDED ACCELERATED PROGRAM

To carry out the total needed program in the Salt-Wahoo watershed within a 10-year period will require an acceleration of work above the current programs, and will require the installation of measures not now included in current programs of the Department of Agriculture.

In table 8, there are set forth the additional items of work and estimated costs that will be required in addition to current programs to carry out the job in 10 years.

TABLE 8.—*Recommended accelerated program, Salt-Wahoo Creeks watershed*

[Long-term projected prices]

Measures	Unit	Quantity	Installation costs			
			Federal	Non-Federal public	Private	Total
Conversation and improvement measures:						
Crop and grasslands:						
Seeding grasses and legumes.....	Acre.....	119, 500	\$645, 300		\$788, 700	\$1, 434, 000
Crop residue management.....	do.....	117, 700			58, 900	58, 900
Contour farming practices.....	do.....	427, 000				
Terraces.....	Mile.....	25, 800	1, 935, 000		1, 935, 000	3, 870, 000
Seeding of pastures.....	Acre.....	184, 000	993, 600		1, 214, 400	2, 208, 000
Pasture management.....	do.....	228, 000				
Pasture clearing.....	do.....	5, 600			140, 000	140, 000
Livestock watering facilities.....	Number.....	1, 145	251, 900		206, 100	458, 000
Contour furrowing or pitting.....	Acre.....	127, 100	127, 100		381, 300	508, 400
Lime.....	do.....	95, 000	313, 500		256, 500	570, 000
Fertilizer.....	do.....	326, 000	815, 000		815, 000	1, 630, 000
Outlets and waterways.....	Mile.....	2, 280	615, 600		410, 400	1, 026, 000
Erosion-control structures.....	Number.....	1, 010	711, 700		582, 300	1, 294, 000
Diversions.....	Mile.....	710	138, 450		74, 550	213, 000
Fencing.....	do.....	400			180, 000	180, 000
Drainage.....	Acre.....	5, 000	20, 000		70, 000	90, 000
Farm wood lots, shelter belts:						
Farm wood lot and special farm plantings.....	do.....	10, 000	151, 300	\$60, 500	393, 500	605, 300
Windbreaks and shelter belts.....	do.....	5, 730	177, 600	71, 000	461, 600	710, 200
Wildlife habitat improvement.....	do.....	940	10, 500	73, 300	21, 000	104, 800
Interplantings.....	do.....	1, 800	18, 100	7, 300	47, 100	72, 500
Timber-stand improvement.....	do.....	5, 200	8, 200		32, 900	41, 100
Technical assistance.....			1, 795, 800	103, 300		1, 899, 100
Educational assistance.....			168, 000	22, 000		190, 000
Administration of direct aids.....			537, 980			537, 980
Research, land and water resources.....			1, 346, 600			1, 346, 600
Measures for stabilizing small water-courses:						
Upstream floodwater-retarding reservoirs.....	Number.....	165	2, 211, 200	105, 000	140, 600	2, 456, 800
Tributary channel improvement.....	Mile.....	142	162, 500	57, 900	11, 800	232, 200
Stabilizing and sediment control structures.....	Number.....	2, 376	3, 012, 100	514, 300	238, 700	3, 765, 100
Subwatershed waterway improvement.....	Mile.....	968	821, 200	460, 600	86, 800	1, 368, 600
Total.....			16, 988, 230	1, 475, 200	8, 547, 150	27, 010, 580



# SECTION II

## BLUE RIVER WATERSHED (NEBRASKA AND KANSAS)

### CONTENTS

	Page
Scope of report.....	81
Description of watershed.....	81
Economic development.....	85
Watershed problems and goals.....	88
Desirable pattern of land use.....	94
Current status of work.....	95
Total needed program.....	87
Program appraisal.....	110
Economic justification.....	113
Recommended accelerated program.....	114

### LIST OF TABLES

Table	
1. Average annual damage.....	94
2. Use of agricultural land, present and planned.....	95
3. Cost of research, soil surveys, and land classification.....	107
4. Total needed program.....	110
5. The recommended accelerated program.....	115



## SECTION II

### BLUE RIVER WATERSHED (NEBRASKA AND KANSAS)

#### SCOPE OF REPORT

There is set forth in this section a program for the conservation, development, and use of the lands of the Blue River watershed. One of the principal goals is to protect the highly productive lands and to increase agricultural production without impairing permanent productivity. Closely associated with this objective is the reduction of flood damages that will come from the application of the program outlined and recommended in this report for application on the land and on the watercourses of the watershed.

It is the purpose of this report to describe the Blue River watershed, to set forth the scope of the recommended program and its costs, and to appraise the benefits and results that will come from its application and installation.

The report provides a reliable basis for recommending a satisfactory framework for preparation of annual work plans for accelerating certain phases of work and initiating the installation of other needed measures that will not be carried out under current programs of the Department of Agriculture.

#### DESCRIPTION OF WATERSHED

##### LOCATION AND SIZE

The Big Blue River, a tributary of the Kansas River, rises in the loess plains of south-central Nebraska and flows east and south to its junction with the Kansas River near Manhattan, Kans. (map 1). The watershed has an area of 9,600 square miles, of which 7,216 are in Nebraska and 2,384 in Kansas. The principal tributaries of the Big Blue River are Little Blue River, 3,497 square miles; West Fork, 1,259 square miles; and Turkey Creek, 786 square miles. All of these streams enter from the west. The Black Vermillion River, with a drainage area of 507 square miles, is the only important tributary entering the Big Blue from the east.

##### TOPOGRAPHY AND VALLEY CHARACTERISTICS

The topography of the watershed ranges from nearly level to hilly, with gently rolling to rolling topography predominating. The hilly areas are confined to comparatively narrow belts bordering the lower reaches of the more deeply entrenched streams. Elevations range from 2,190 feet mean sea level in the headwaters of the Little Blue River to about 990 feet at the mouth of the Big Blue. The valley of the Big Blue at Stromsburg is about 0.3 mile wide and the bottom land is approximately 30 feet below the general upland level. Below Stromsburg, the valley becomes broader and deeper and the edges



more blufflike until in Kansas it is about 200 feet deep on the average with bottoms, including terraces, ranging from 1.5 to 2 miles in width. The gradient of the main stream averages 2.8 feet per mile. The Little Blue has an average gradient of 5.3 feet per mile. The stream rises on nearly flat, poorly drained uplands separating the Blue River drainage from the Republican drainage to the south and west. Bottom-land development in the Little Blue starts near Roseland and widens to about a mile, including terraces, at Hebron and to 1.5 miles at Hanover. The terraces make up about 75 percent of the bottoms and lie above ordinary flood-crest levels.

#### CLIMATE

The eastern part of the watershed lies within a belt of moist sub-humid climate running from the Gulf of Mexico north through the central United States into Canada. The western portion lies in a parallel dry-subhumid belt distinguished by the fact that in ordinary years rainfall does not exceed losses by evaporation and the needs of plants. The average annual precipitation varies from 32.03 inches at Manhattan near its mouth to 22.62 inches at Minden in the headwaters of the Little Blue, and 27.78 inches at David City in the upper headwaters of the Big Blue. There is considerable variation in annual precipitation received at any one station as shown in the table that follows. Approximately 76 percent of the rainfall occurs between April 1 and September 30. May, June, and July are generally the months of heaviest rainfall. Snowfall is seldom of sufficient volume to cause flooding of any serious consequence.

Recorded temperature extremes range from 118° F. to -30° F. The frost-free growing season ranges from 155 to 171 days.

Station	Temperature ° F.		Average number of days growing season	Precipitation (inches)		
	Maximum	Minimum		Average annual	Driest year	Wettest year
Manhattan, Kans. -----	116	-32	171	32.03	15.13	50.82
Minden, Nebr. -----	118	-33	155	22.62	12.59	40.06
David City, Nebr. -----	114	-30	161	27.78	11.49	44.80

#### GEOLOGY AND SOILS

The bedrock formations in the watershed consist of nearly level alternating beds of limestones, sandstones, and shales. In the lower portion of the watershed, the bedrock formations are of Permian age. Above this formation and progressively toward the headwaters are limestone, shale, and sandstone strata of Cretaceous age. Ogalalla sands of Tertiary age overlie the Cretaceous formations in the upper headwaters area. The mantle rock formations consist of deep loess deposits which cover most of the northern and western portions of the watershed and of glacial till overlain in places by loess in the southeast portion.

The soils in the watershed range from deep types developed on loess and glacial materials to shallow types developed on residual limestones, shales, and sandstones. The section of the watershed lying



west and north of the towns of Hebron and Crete, Nebr., is largely a broad, nearly level loess plain. It occupies roughly 65 percent of the watershed area. The soils developed in this area are predominantly deep, friable types with good infiltration and high moisture-holding capacities. Notable variations from these types occur in Clay and Fillmore Counties where most of the area is made up of thick soils with heavy subsoils. These areas are greatly restricted in their infiltration capacities. An estimated 14 percent of the area is level to depressional with little or no surface drainage. Here the soils have well-developed claypans. Erosion in this area is generally slight to moderate; but severe sheet and gully erosion is prevalent in the steeper areas under cultivation.

An area of loess-capped glacial till characterized by predominantly rolling topography centers in Jefferson, Saline, and Gage Counties, Nebr.; and Marshall County, Kans. It occupies about 10 percent of the watershed area. Here the soils are mainly thick, well-developed types with moderate infiltration capacities. Claypan types occupy the level and depressional areas of the broader divides, and soils with thin surface layers occupy the steeper slopes along drainage ways. The drainage pattern in this area is very well developed in contrast to the area previously described. Sheet erosion ranges from moderate to severe on the rolling cultivated lands and gully erosion is active in both cultivated and noncultivated areas.

The western part of the watershed in Kansas and extending into Jefferson and Thayer Counties, Nebr., is a rolling loess-capped plain characterized by outcrops of residual limestones and sandstones along the breaks and hills adjacent to the more deeply entrenched drainage ways. It occupies approximately 14 percent of the watershed area. The loess soils in this area normally have thick, very dark silty surfaces and friable, slightly heavier subsoils. The soils developed from limestone and sandstone are largely shallow and their use should be limited generally to grazing. A considerable area of such soils occur in the Kansas portion of the watershed. Sheet erosion ranges from moderate to severe on cultivated lands, depending on topography and intensity of use. Gully erosion is active, but headward cutting and deepening is retarded where the bedrock lies close to the surface.

Alluvial soils, including terraces, make up about 11 percent of the watershed area. They consist to a large extent of highly productive silt loams and sandy silt loams with local gravelly phases. Extensive alluvial terraces, ranging in height from 20 to 35 feet above low-water level, occupy much of the valley bottoms of the Big Blue and Little Blue Rivers. The terraces lie above ordinary flood-crest levels and thereby limit most overbank flooding to a relatively narrow belt of bottom land along these streams.

#### NATIVE VEGETATION

Prior to the arrival of the white men in the watershed, the native vegetation consisted mainly of a luxuriant growth of prairie grasses on the uplands and trees along the watercourses and the steeper areas bordering them. The upland grasses included principally such varieties as buffalo grass, blue grama, side oat grama, western wheat grass, little blue stem, needle grass, June grass, and prairie dropseed. The tall prairie types dominated the lower part of the watershed and



the short grasses the western part. Big bluestem, Indian grass, and wild rye were found abundantly along the better-drained bottoms. The forest growth consisted largely then, as today, of cottonwood, elm, black walnut, black oak, and soft maple in the lower sites and bur oak on the steeper slopes. Existing woodlands provided a supply of wood which could be used for several purposes. High-grade walnut logs were sold to furniture and other wood-using industries and stands of merchantable timber were exploited for rough lumber posts, and fuel in supplying local needs. As farming expanded, osage orange hedgerows were established as fences and field windbreaks which also furnished a supply of excellent fence posts.

## ECONOMIC DEVELOPMENT

### HISTORY

Prior to about 1850, the white population of the watershed was limited to a few cattlemen located in the southern portion of the watershed. During the late forties, a few permanent settlers began establishing homes. They plowed up the native sod and earned a living by producing grain crops and livestock. During the fifties, they had become sufficiently established in the Kansas portion of the watershed to start organizing the territory into counties. Riley, Marshall, and Nemaha Counties were the first to earn this distinction. They were organized in 1855. Settlement of the watershed progressed to the north and west and was completed soon after 1870. The Oregon Trail from St. Joseph, Mo., to Fort Laramie passed through the watershed, and many of the early settlers were families who had started west but dropped out of caravans as they passed through the watershed and remained to establish permanent homes. The period from 1870 to 1890 was a period of expansion and population increase. Railway transportation was extended, additional land brought under cultivation, and the one-time prairie became an area of general livestock and cash grain farming as it remains to this day.

The early settlers took full advantage of the woodland cover in locating their home sites. Many of the early settlers planted trees around their farmsteads for beautification and protection purposes. The general interest in the establishment of trees on the farms is exemplified by the creation of Arbor Day in Nebraska in 1872 and in Kansas a few years later. The passage of the Clarke-McNary Act in 1924, which authorized Federal and State cooperation in farm plantings and the establishment of the Prairie States' forestry project in 1935, accelerated the planting of trees in rural areas. As a result of Federal and State programs, there has been a slow but steady increase in the net acreage in trees.

### POPULATION

The 1940 census gives a total population of approximately 212,000 for the Blue River watershed. Of this total, approximately 100,200, or 47.3 percent, live on farms. Hastings, Nebr., with a population in excess of 25,000, is the largest city in the watershed. Beatrice, Nebr., is next largest with a population exceeding 15,000.

## TRANSPORTATION AND COMMUNICATIONS

The watershed is well served by main or branch lines of the Union Pacific, Missouri Pacific, Chicago, Burlington & Quincy, Chicago, Rock Island & Pacific, and the Chicago & North Western Railroads.

There are an estimated 870 miles of hard-surfaced Federal and State highways and many more miles of gravel roads traversing all sections of the watershed.

Commercial bus and truck transportation serve much of the area, and commercial and municipal airports are located at a number of towns in the watershed.

Electric power, telephone, and telegraph services are available to all parts of the watershed, and radio stations are located in the larger cities. A high proportion of the farms are electrified.

## SIZE AND TYPE OF FARMS

There are 25,562 farms in the watershed according to the 1945 agricultural census. The median-sized farm includes approximately 200 acres. By size category, about 16 percent of the farms are smaller than 100 acres; 37 percent include 100 to 219 acres; 35 percent include 220 to 379 acres; 10 percent contain 380 to 699 acres, and less than 2 percent are 700 acres or over in size. The climate of the watershed is well suited to the production of corn and grain, and most of the farmers follow a general livestock and cash-grain system of farming.

## LAND OWNERSHIP AND TENURE

Nearly 99 percent of the area of the watershed is held in private ownership. The balance is owned or administered by the Federal and State Governments. An estimated 52 percent of the farms are operated by part and full owners. The remaining 48 percent are tenant operated.

## FARM VALUATION

According to the 1945 agricultural census, farm land and improvements in the watershed represents a capital value of about \$366,300,000. The capital investment per farm in the watershed is \$14,330 as compared to the average of \$14,500 for the two-State area of Kansas and Nebraska.

The financial position of the farmers in the watershed has been strengthened during the recent period of favorable yields and prices. The drought years and low farm prices prior to 1941 resulted in a high farm debt in relation to values of farm land and farm commodities. The increase in farm prices since 1941 has resulted in a greatly expanded farm income and increased ability to pay off the accumulated debt.

## PRESENT LAND USE

Approximately 69 percent of the agricultural land in the watershed is cropland, about 29 percent is permanent grassland, and 2 percent is woodland and wildlife area. There is considerable variation in the use of agricultural land throughout the watershed. In general, there is a much larger proportion of cropland to grassland in the northwest half of the watershed than in the southeast half and the percentage of inter-

tilled crops to other cultivated crops is also greater in the northwest half.

### *Cropland*

For the watershed as a whole, about 53 percent of the cropland is presently devoted to intertilled crops, 40 percent to small grains, and 7 percent to rotation hay and pasture. In the northwestern portion, however, intertilled crops occupy about 60 percent, with about 32 percent small grains. The eastern and southern portions have about 45 percent in intertilled crops and 48 percent in small grains. Cropping practices in the watershed vary from the most progressive types to those which are very conducive to soil deterioration. Because of steep slopes, shallow soils, and severe erosion conditions, a considerable area now under cultivation should be retired to grass and woods. The establishment of soil-conservation districts, together with activities of the Extension Service and the Production and Marketing Administration, have aided greatly in more recent years in getting conservation measures established on the land. During the drought years of the 1930's and since that period, a considerable amount of pump irrigation was developed, particularly in the northern half of the watershed. It is estimated that approximately 60,000 acres are under irrigation in the watershed.

### *Pasture*

Over half of the pasture land in the watershed is in "poor" condition, both from the standpoint of runoff and erosion control, and the production of forage for grazing. About 12 percent is classified in "excellent" condition, 34 percent as "good", and 54 percent as "poor." In the western portion of the watershed, 80 to 90 percent is in poor condition. The pastures throughout the watershed have been overgrazed and poorly managed over a period of years, and are contributing to flood, erosion, and sediment damage. Special attention needs to be given to these pastures, which presently occupy about 30 percent of the land in the watershed.

### *Woodlands*

The area classified as woodland totals approximately 131,000 acres, of which 87 percent is in native stands of timber. The remainder is composed largely of field shelter belts, farmstead windbreaks and hedgerows, and lesser amounts in special erosion-control plantings and wildlife cover. The existing stands of native timber are much inferior in comparison with those which originally grew on these lands. Repeated cuttings, poor cutting practices, continued grazing, and other destructive influences have changed the composition and density of the stands. In many areas some of the more valuable species such as black walnut have been replaced by inferior species, and the annual growth has dropped considerably below the productive capacity of the land. This situation is reflected in the fact that the timber resource in the watershed is now supplying not more than 5 percent of the local demands for wood products in contrast to possible productive capacity of 20 percent.

Additional shelter belts and windbreaks should be established, as field studies indicate that only 35 percent of the needs for these types of plantings are now in place.



In designing the woodland features of the program, there is an important economic consideration which should not be overlooked. Much of the area that is now in trees or suitable for planting is located along the stream bottoms where overflows occur during periods of high water. These lands are well adapted for the growing of valuable species such as black walnut and, with the local demands for various wood products, there are excellent opportunities to increase the returns from this form of land use.

The development and improvement of wooded areas will be beneficial to wildlife in providing food and shelter for such small animals and game birds as squirrels, rabbits, quail, and pheasants.

#### WATER SUPPLY AND USE

Water supplies of good quality and in sufficient quantity for domestic and municipal use are available throughout the watershed from underground sources. Only two towns in the watershed are known to be dependent upon surface water for their municipal supply. The other towns and cities have been able to secure adequate supplies from valley alluvium or from bedrock aquifers. In the northern and western parts of the watershed, the underground formations yield sufficient water for farm irrigation systems, and numerous wells producing adequate yields of water of suitable quality for irrigation are being installed each year. Approximately 850 pump irrigation wells have been installed in the watershed, many of which are connected with electric motors energized from REA power lines.

#### FISH AND WILDLIFE

Wildlife in the watershed are those usually found in highly developed farming areas. The Chinese pheasant, an introduced species, is very well established and has provided excellent hunting for many years. Native game includes quail, ducks, rabbit, and squirrel. Abundant feed and many shallow lakes make the watershed a desirable mecca for migratory wild fowl. Fish are limited mainly to catfish which are to be found in the Blue River.

The production of wildlife, and of fish in particular, could be brought to a much higher level than presently exists by improving habitat. Although cover provided by cultivated crops and grasses is usually abundant throughout the late growing season, only a comparatively small proportion can be classed as year-around undisturbed cover. Practical means and solutions for improving habitat are known and are being employed. Their application can be significantly increased.

#### WATERSHED PROBLEMS AND GOALS

There has been a continuous decline in the productivity of the land and in its ability to absorb and hold moisture since the completion of settlement in about 1870. This decline is reflected in lowered crop yields and increased propensity to flooding resulting from the misuse and mismanagement of watershed lands, including such practices as cultivating land that is too steep, farming up and down the slopes, burning of crop residues and woodlands, overgrazing grasslands, and

the grazing of woodlands. The deterioration of watershed conditions was greatly accelerated during and immediately following World War I when misuse and mismanagement of land was widely practiced as a means of supplying the food needed to meet the demands of the wartime economy. These forms of exploitative use of land were further encouraged by the combination of favorable climatic conditions and high prices prevailing at the time. The accelerated decline continued into the thirties when low prices coupled with severe drought encouraged the further misuse of land.

The actual decline in the productivity of the land through loss of topsoil has in part been offset, and the effects obscured, by the introduction of improved crop varieties and the increased use of commercial fertilizers. The improvement in varieties and increased use of fertilizers cannot, however, be expected to keep pace with continued decline resulting from the misuse of land. The alternative, for the maintenance of permanent productivity, requires that increased emphasis be directed to getting more rapid application of works of improvement and improved land-use measures and techniques that will conserve soil by curbing erosion and that will increase crop production and reduce damages from flooding by improving the permeability and moisture-holding capacity of the soils. This will require an increase in technical assistance to step up the rate of planning and application of land-treatment measures, and will also require Federal funds for installation of structures needed to stabilize drainage ways and to reduce annually recurring damages resulting from floods brought about by unstable watershed conditions.

The midthirties saw the close of an era during which there was a general lack of appreciation of the need for conservation of our land resources. Since that time, there has been an ever-increasing awareness on the part of farmers and of business and professional men in local communities of the need for improved land-use and management practices to prevent further deterioration of the soil resources and to reduce damages from flooding. In recognition of these problems and of the urgent need for action, landowners and operators are making widespread use of every facility offered to help solve them. Most operators have taken advantage of financial aids offered by the Department of Agriculture to help get conservation work started on their lands. Many are benefiting greatly through educational meetings, literature, and other assistance made available to them through their local and State extension agents. A number of counties in the watershed were among the first organized into soil-conservation districts in the States of Kansas and Nebraska, and all counties in the watershed are now so organized. These districts have made an excellent start in the planning and application of practices on individual farms. In some counties the requests for technical help far exceeds the technical assistance presently available to meet all demands. In a number of localities farmers and business and professional men have organized into watershed groups to promote and assist in the speeding up of conservation and runoff-control measures on a watershed basis.

Installation of the program for improvement of agricultural lands and woodlands entails sizable investments for farm owners and operators. Part of the returns from the investment will be in the form of maintenance and improvement of soil, woodlands, and other resources which will be shared by many, including the original investor, the



ensuing landowners, off-farm interests, and future generations. Some measures may not return the investor sufficient income during his tenure to justify the investment unless he can pass to future landowners the increase in capital value resulting from such investments. There are uncertainties of realizing this increase in capital investments in the land. Opportunities for investments which promise nearly immediate cash return will cause some farm operators to be reluctant to bear a large share of the cost of installing those measures which may not yield returns of a sufficient rate to amortize the investment during their period of occupancy.

The total needed program will greatly increase the production of livestock feed crops throughout the watershed. To utilize the increased production, additional investment in livestock will be required. In some cases this will require additional investment in buildings and farm equipment. Even though the returns on the investments yielding the increased crop and pasture production is realized nearly immediately, the capital needed for additional equipment and livestock investments will be relatively large and may require new mortgages. This will retard the installation of the full program at the accelerated rate on farms that have been operated as cash grain farms and on farms operated by young men who have not yet had time to accumulate working capital.

The program recommended for the Blue River watershed, therefore, proposes that the public shall bear a sufficiently large share of the cost of installing the measures to encourage installation of the full program. It also proposes that landowners and operators continue to carry their equitable share of the costs. The Department will expect to serve the needs of farmers for credit through its authorized credit programs. The whole program is based on voluntary cooperation as is true of current programs.

#### FLOOD PROBLEMS

The earliest flood of record on the main stem of the Blue River occurred in 1886. The next flood was reported in 1902 and since that time floods on the main stem have occurred on an average of about once every  $2\frac{1}{2}$  years. During the years 1950 and 1951, the Blue River experienced floods which exceeded previous records and caused very severe damages. High flood stages occur with greater frequency on tributary streams than on the main stem, and, in recent years, damaging flood stages have occurred at one or more places in the watershed each year.

Flood flows in the lower part of the watershed are usually caused by heavy general rains, while in the upper reaches they may be caused by general rains or by excessive local rainfall. The period May 1 to July 15 is the period of heaviest rainfall and most serious flooding. Damages from these flood-producing storms occur first on the upland areas in the form of sheet and gully erosion, washed-out crops, and delays in seeding or cultivating crops. The runoff water from the upland fields overflow the channels and inundate the flood-plain lands, causing damage to the land itself, to crops, and other agricultural property, to urban and industrial developments, and to roads and railroads. In addition to these damages, there are many indirect damages which occur as a result of the floods. They include such



items as disruption of normal activity in the flooded area and the surrounding region, loss in weight and condition of livestock, loss of wages, spreading of noxious weeds, depreciation in property values, decreased efficiency in use of labor and machinery, disruption of traffic, and many other economic disturbances.

#### FLOOD DAMAGES

Estimates of average annual damages in the Blue River watershed are presented in table 1. The figures include damages to authorized reservoirs but do not include estimates of damages for areas to be protected by such reservoirs.

Three main categories of damages have been evaluated. These are land damage, inundation damage, and sediment damage. Of the total damages evaluated, 2.5 percent represents damage to land from erosion; 92.4 percent represents damage from inundation, and 5.1 percent damage from sediment.

##### *Inundation damage*

Damages described under this heading fall into two main classes: agricultural and nonagricultural. The nonagricultural damages include damages to roads only. Other nonagricultural damages such as urban, railroad, and utility damage have not been evaluated.

*Agricultural.*—Agricultural damages evaluated consist of damage to crops and pastures; to farm improvements, including farm buildings and contents, fences, farm roads and bridges, farm water supplies, farm machinery; and livestock. The flooding of crops comprises the major agricultural damage in the watershed. These damages include complete loss of crops and reductions in yields of crops due to flooding and reduction in yield due to delayed planting. Replanting after floods is a common practice and results in increased production costs and usually a reduction in net return. The grazing capacity of pastures is greatly reduced by inundation, particularly along the larger streams where flooding is usually prolonged. Silting is a frequent cause of reduced grazing capacity of pastures.

Debris carried by floodwater and deposited on cropland entails the cost of removal and frequently delays planting operations. Fence damage is widespread, resulting in large expenditures for labor, materials, repairs, and replacement. Damaged fences cause temporary loss of pasture and livestock damage to crops.

*Nonagricultural.*—Nonagricultural damages evaluated for the Blue River watershed include damages to roads and bridges only. The county roads and bridges are generally not designed to withstand unusual flooding and are therefore particularly vulnerable to inundation damage. The repair of county facilities is often delayed because of lack of funds thus adding materially to the damage and inconvenience.

##### *Land damage*

This damage category includes those types of damages which result in the loss or destruction of land and in the lowered productive capacity of land. It includes land destruction of uplands by gullying but does not include a monetary evaluation of damage by sheet erosion. Both sheet and gully erosion are problems of serious concern in the Blue River watershed. Virtually all of the area under cultiva-

tion has been moderately to severely eroded. The exceptions are the nearly level to depressional areas and even here occasional shallow gullies have been formed. In the areas of intensive drainage development a considerable proportion of the eroded materials are transported and deposited along the main stems of the drainage system.

*Sheet erosion.*—The loss of topsoil by sheet erosion is a problem of particular concern in those areas where the gradual removal of the thin capping of highly productive loess is exposing the undeveloped and much less productive underlying glacial and residual soil materials. This soil loss has permanently reduced the productivity of large areas in the watershed. In some places and in association with gully erosion, it has exposed large source areas of infertile sediments in steeply sloping areas bordering drainageways. Besides the effects of reducing the productivity of the area and adding to the sediment load of streams, sheet erosion seriously affects the ability of the soil to absorb and store water. Sediment, a residuum of sheet and gully erosion, is the cause of considerable damage to crops, bottom lands, and on-stream installations. Since the principal damage by sheet erosion is that reflected by the reduction of the productivity of the land, the evaluation of this damage is contained in the estimate of the gross increase in income from the lands of the watershed which can be expected following the application of the program. This increase in income is termed the "conservation benefit."

*Gully erosion.*—Gullies have destroyed an estimated 13,000 acres in the Blue River watershed. A much larger acreage has been depreciated because of the dissection and subsequent restrictions of use for cultivation. Even though badly dissected cropland may not be soon abandoned, the increased costs of operation eventually make continued cultivation of such areas unprofitable. The loss of income because of increased costs of production and lower productive land use was not evaluated. The damage figure reflects only the gully voids and the turnrow strips adjacent to the gullies which cannot be farmed. Head-cutting gullies from 15 to 30 feet in depth are common occurrences in some of the more steeply sloping areas. In some cases such gullies have cut deeply into infertile sandy materials and are the source of considerable sediment damage along the stream bottoms and particularly along the Little Blue River. Gully erosion, like sheet erosion, is most severe in the more rolling southeastern portions of the watershed. The residuum of gully erosion is evaluated under sediment damages.

*Stream-bank erosion.*—Stream-bank erosion has removed from production an estimated 3,560 acres of bottom land or about 90 acres annually. It occurs throughout the watershed, but is more severe in the southeast third of the watershed and along the Little Blue River.

*Flood-plain scour.*—Flood-plain scour is prevalent throughout the watershed and particularly along the larger streams. It is most prominent in the flood plain along the Little Blue. In most cases the scour is in the form of an overflow channel on the flood plain. Forty percent of the productive capacity has been lost on an estimated 14,000 acres of bottom lands in the watershed.

#### *Sediment damage*

The products of soil erosion impair productivity of the bottom lands, reduce the storage capacity of reservoirs, and damage trans-

portation facilities. The principal source of harmful sediment is sheet erosion with gully erosion, stream-bank erosion and flood-plain scour contributing to a lesser degree. Harmful sediment deposits are constantly reducing the productive capacity of the flood plain and thereby reducing the income from this land.

*Infertile overwash.*—Infertile overwash, the deposition of less fertile or harmful sediment on bottom-land soils, has damaged an estimated 72,300 acres; and reduced its productive capacity about 20 percent. The greatest damage by infertile overwash is found in the southern part of the watershed along the Little Blue River and some of its larger tributaries.

*Swamping.*—Swamping damage occurs primarily in the eastern part of the watershed. Approximately 6,500 acres of bottom land have been damaged an average of 55 percent by swamping. The damage results from sediment deposits in the channel and on flood plains. The materials deposited in the channels raise the water table, and material deposited adjacent to stream channels form natural levees obstructing surface drainage. Clay and silt deposits have progressively impaired internal drainage.

*Reservoirs and farm ponds (existing).*—There are no existing reservoirs in the Blue River watershed. There are some small dams constructed for local power use but they use only the natural stream flow for power generation. The loss of capacity has little if any effect on this type of structure. There are about 690 farm ponds in the watershed, but since all benefits are on-site benefits, these were not evaluated.

*Reservoirs (authorized).*—Tuttle Creek Reservoir is the only reservoir in the watershed authorized to be built by Federal funds. The sediment damage to this reservoir has been evaluated in terms of reduction in storage capacity. The rate of storage loss for this reservoir when built is estimated at 3,700 acre-feet per year.

*Water-treatment costs.*—Water-treatment costs for municipal water supplies are increasing because of filtration of suspended sediment. Two cities are adversely affected by the sediment load of streams.

*Transportation facilities.*—Transportation facilities consisting of approximately 1,650 miles of railroad and 16,000 miles of roads are subject to damage by sediment and floodwater. Removal of sediment deposits from highways and railway ditches, culverts, and roadbeds, greatly increases the cost of maintaining these facilities.

#### *Indirect damage*

Unevaluated damages include interruptions to communications, traffic, trade, and manufacturing; costs of flood relief, policing, sanitation, restoration of public works, and various other demands on public funds and services; disruption of schools and other public institutions; general dislocations in social and economic relations; damage to fish, wildlife and recreational values; and loss of life. Prodigious numbers of mosquitoes are produced as a result of floods. The floodwater mosquito (*Aedes vexans*) is the most common and formidable pest of man and livestock in the Missouri Basin.



TABLE 1.—Average annual damage, Blue River watershed

[Long-term projected prices]	
Type of damage	Average annual damage
Land damage: <sup>3</sup>	
Gully erosion and valley trenching.....	\$44, 647
Stream-bank erosion.....	12, 499
Flood-plain scour.....	114, 481
Subtotal.....	171, 627
Inundation damage:	
Agricultural.....	4, 732, 027
Nonagricultural <sup>1</sup> .....	1, 521, 547
Subtotal.....	6, 253, 547
Sediment damage:	
Deposition of infertile overwash.....	217, 131
Swamping.....	32, 574
Water-treatment costs.....	5, 593
Subtotal.....	255, 298
Reservoir authorized <sup>2</sup> .....	91, 476
Total.....	6, 771, 975

<sup>1</sup> Road and bridge damage only. Damages to urban property, railroads, and utilities have not been evaluated.

<sup>2</sup> Damages based on Corps of Engineers' cost estimates for Tuttle Creek Reservoir as shown in H. Doc. 642 81st Cong., 2d sess.

<sup>3</sup> This does not include sheet-erosion damage.

### DESIRABLE PATTERN OF LAND USE

The "total needed" program recommended in the report is based on the principal of use of each acre of agricultural land within its capabilities, and the treatment of each acre in accordance with its needs for protection and improvement; the attainment of increased production consistent with the maintenance of the soil resource, and the reduction of floodwater and sediment damage. To attain this objective, it will require the conversion of some cropland to pasture, woodland, and other permanent cover; and pasture to cropland and woodland. These conversions are based upon reconnaissance conservation surveys covering the entire watershed.

The net effect of placing each acre of the agricultural land in the watershed in its proper use would result in a reduction of about 617,000 acres, or 15 percent in cropland; an increase of 521,000 acres, or 26 percent in pasture; and an increase of 100,000 acres, or 77 percent in woodland.

Crop rotations supported by terracing, contouring, and adequate water-disposal systems will be of major importance in reduction of runoff and sediment production, inasmuch as 58 percent of the agricultural land is recommended to be in cropland. The recommended crop rotations will effect an over-all decrease of 750,500 acres, or 35 percent in intertilled crops; 156,000 acres, or 10 percent decrease in small grains; and 290,300 acres, or 100 percent increase in rotation hay and pasture.

Present and planned use of agricultural land is shown in table 2.

TABLE 2.—*Use of agricultural land, present and planned, Blue River watershed*  
[Percent]

Use	Present	Planned
Intertilled crops .....	36.2	23.3
Small-grain crops .....	27.7	25.0
Rotation hay and pasture .....	4.9	10.0
Total cropland .....	68.8	58.3
Permanent grassland .....	29.0	37.8
Woodland .....	2.2	3.9
Total .....	100.0	100.0

## CURRENT STATUS OF WORK

### ACTIVITIES AND ACCOMPLISHMENTS TO DATE

The Department of Agriculture, State, and local agencies interested in the development of land and water resources in the watershed are cooperating in providing landowners and operators with technical services, educational and research assistance, credit and direct aids in connection with fulfilling the Federal responsibility for conservation of the soil, forest, and water resources and for increasing the productivity of the watershed lands.

Through soil-conservation districts, assistance is being given to individual farmers and groups of farmers in the application of measures included in the district program. This includes measures for soil and water conservation, for improvement and maintenance of soil productivity, and for other purposes relating to land management. Soil-conservation districts have already been established in all the counties in the watershed. These districts, organized under State enabling acts, provide local leadership and a legal body through which farmers can join together in establishing soil-conservation practices and improved methods of agricultural production.

In all counties in the watershed, assistance is given farmers in carrying out practices designed to control erosion and maintain fertility of soil resources. The current program includes financial assistance, technical assistance, and educational help to encourage establishment of improved practices.

Several State and Federal agencies are contributing to a limited extent to forestry activities in the area by supplying technical advice, educational assistance, distributing planting stock, and by direct aids to encourage tree establishment and care. The Extension Service in Nebraska provides educational assistance and advice. In Nebraska the Extension Service also handles the distribution of planting stock which is available to landowners under the Clarke-McNary program. The State fish and game commissions are responsible for the development of wildlife requirements and are establishing plantings to improve wildlife habitat. As a result of the activities of the various agencies, there has been an increase of woodlands in the watershed amounting to about 300 acres annually during the past few years, and also noticeable improvements in the management and use of some of the existing wooded areas.

The Agricultural Extension Service has offices in every county in the watershed and is providing educational assistance to landowners

and operators relative to the objectives and needs for the recommended program. Only a small part of the educational work that will ultimately be required to create a realization of the need for the complete program of land-treatment measures, and especially to install the measures for stabilizing small watercourses, has been done.

#### CURRENT RATE OF PROGRESS

Much has already been done under the Department's current programs to establish conservation measures on the lands of the watershed, but a greater amount remains to be done. Conservation plans have been prepared for a total of 5,937 farms. Many more farms are carrying out individual conservation practices. However, only a relatively small percent of the lands in the watershed are estimated to have adequate conservation programs established. The installation of adequate conservation measures is being retarded in some areas by a lack of waterway grade control. In general, the measures necessary to achieve grade control of small watercourses, which require large capital investments and participation by groups of farmers, are not being installed under the current programs. The program recommended in this report calls for the installation of waterway stabilizing works which will aid greatly in accelerating the establishment of complete conservation programs on farms and ranches throughout the watershed.

#### ANNUAL EXPENDITURES UNDER CURRENT PROGRAMS

The Department of Agriculture is currently spending an estimated \$1,215,000 annually in the watershed in the form of technical and educational assistance and incentive payments for those parts of the current program which contribute to the objectives of the recommended program. The major proportion of this expenditure is in the form of payments made to assist farmers in getting conservation established on their lands.

#### ESTIMATED TIME REQUIRED TO COMPLETE INSTALLATION OF THE TOTAL NEEDED PROGRAM

It is estimated that a period in excess of 100 years will be required to complete installation of all items included in the "total needed" program (table 4) at current rates of progress. The number of years required to install individual measures varies greatly. The period for complete establishment of the purely agronomic practices at current rates ranges from 33 years for crop-residue management to 139 years for seeding of pastures. It is estimated that establishment of green manure and cover crops will take 103 years and establishing grass and legumes in the rotation 62 years. The complete application of fertilizers will require 48 years and lime 55 years. The installation of outlets and waterways will take 58 years and terracing 63 years. Development of livestock-watering facilities can be completed in 23 years. Present rates of woodland establishment are very minor in relation to needs and restoration of badly deteriorated native woodlands is negligible. Very few measures requiring group action for stabilizing small watercourses are being installed, and at present rates the job may never be completed.



## TOTAL NEEDED PROGRAM

The total needed program herein recommended (table 4) includes the intensification, acceleration, and adaptation of certain activities under current programs of the Department, and additional measures not now regularly carried out in such programs, all of which are necessary to complete a balanced runoff and water-flow retardation and erosion-control program for the watershed. It also provides for the effective integration and coordination of these programs and activities. The current activities of the Department of Agriculture are included in the total needed program. Estimates are based on current programs continuing at present rates during a 20-year installation period. The recommended accelerated program (table 5) as set forth in this report includes the estimated costs and amounts of work over and above that which will be done by current programs to complete the program in a 20-year installation period. Since specific additional authority and appropriations will be requested for the recommended accelerated program, the calculated economic justification included in this report is limited to those specific works and measures.

The total needed program is designed to fulfill the Federal Government's share of responsibility to preserve and protect the land, water, and forest resources and to increase the productivity of watershed lands by furnishing technical assistance, information, and other aids to individual farmers and groups of farmers in the application of recommended measures including irrigation and drainage works; helping groups of farmers to organize for the installation of effective land and water-management programs; and to provide for an equitable sharing of costs between the individual landowner and the public in order to insure establishment of the complete program during the period designated for installation.

The estimated quantity of measures needed, the installation costs of the measures, and the apportionment of costs are shown in table 4. The share of the costs to be borne by the land operators, as set out in the tables, includes their out-of-pocket expense plus the estimated value of labor expended; machinery operating costs, including depreciation; and other miscellaneous expenses. The costs of technical assistance, the cost of administration of direct aids, the cost of necessary research and soil surveys, and the cost of extension education required to establish the program in the time specified are shown in lump sums apportioned between Federal and non-Federal agencies.

## CONSERVATION AND IMPROVEMENT MEASURES FOR CROP AND PASTURE LAND

The measures needed on crop and pasture land will provide for land use consistent with conservation of soil resources, and will contribute directly to reduction of erosion and control of runoff. Improved agronomic practices, including soil-conserving rotations, management of crop residues, improvement of pastures, and increased use of fertilizer and lime where needed, are provided for. Supporting practices such as terracing, contouring, and establishment and stabilization of small farm waterways and terrace outlets are included. Some land now used for crops will be converted to pasture, woodland, or wildlife use.

Application of the measures will be accelerated by increased educational work, providing technical services, and providing incentive payments, materials, and other services.

The kinds of measures required for the conservation and improvement of crop, pasture, and woodlands are described in detail below.

#### *Seeding grasses and legumes*

Initial seedings of 691,200 acres of grasses and legumes and 648,800 acres of green manure and cover crops are needed on cropland to establish crop rotations adapted to the capability of the land. The crop rotations are basic in the conditioning of cropland for runoff and erosion control, and increased production. These rotations will include, in general, legume and grass mixtures used for hay production or pasture, and annual or biennial legumes used principally for green manure. Legume and grass species to be used will be those able to produce abundant root growth to provide the maximum effect on runoff and sediment production and on soil productivity. The establishment of recommended crop rotations will require adequate lime and fertilizers, which are included in the recommended program.

#### *Contour farming practices*

There are 1,707,000 acres of cropland in the watershed on which farm operations should be carried out on the contour. This includes all land to be terraced, as well as other sloping cropland not requiring or not suited to terracing. On some fields, this contouring will be done in a strip-crop pattern. This measure will permit more intensive use of cropland without land deterioration than would be otherwise possible, and have a favorable effect on crop yields due to increased moisture penetration and more uniform crop stands.

#### *Terraces*

Approximately 87,300 miles of terraces are recommended for construction on cropland which has sufficiently long or steep slopes to produce damaging concentrations and velocities of runoff, and where adequate control cannot be achieved through vegetative practices or less intensive mechanical methods. Graded terraces will be used to conduct the surplus water at nonerosive speeds to be stabilized outlets and waterways provided for in the recommended program. In some fields, diversions will be required for interception and safe disposal of runoff from pastures above. Farm operations on terraced land are to be performed on the contour, and terrace systems will be designed in such a manner as to facilitate contour operations.

#### *Crop residue management*

The use of straw and stubble residue to give erosion protection to 2,893,000 acres is recommended. This measure requires tillage operations that will retain a large part of the straw and stubble at the surface, where these residues help dissipate the force of raindrops, reduce splash erosion, and allow water to enter the soil more rapidly. This measure is also important in helping to control wind erosion which, although not often serious in the watershed, must be guarded against.

#### *Seeding pastures*

The establishment of 849,600 acres of adapted varieties of grasses is recommended on land to be converted to pasture and on present



pasture land where grass stands have been depleted or denuded. This acreage includes areas where natural methods are incapable of restoring suitable vegetation. Fertilizer will be needed for rapid establishment of vigorous stands, particularly on eroded land previously cropped. Some of the acreage will also need lime applications, particularly where legumes are planted with grasses.

#### *Pasture management*

Improved methods of management on 1,915,700 acres of pasture land will increase production and reduce runoff and erosion. The recommended management methods involve adjustment of livestock numbers to give the grass a better chance to grow, and, where a substantial proportion of the desirable forage plants is still present, to improve the stand by natural reproduction. In addition to adjustment of livestock numbers, pasture management will require attention to proper season of use, and in some cases will require rotation grazing and deferred grazing. Pasture-management programs will be worked out farm by farm as a part of the conservation program.

#### *Pasture clearing and mowing*

This measure should be accomplished on approximately 573,100 acres where unpalatable weeds and brushy plants have taken the place of the natural vegetation. Removal of these plants will allow the desirable grasses to become reestablished and enable the pastures to return to their normal productive capacity. Removal of these plants will be accomplished principally by mowing and spraying.

#### *Livestock watering facilities*

An estimated 5,340 livestock water ponds, wells, and springs need to be developed to provide adequate watering facilities for livestock to permit proper distribution of grazing and allow productive use of all pasture lands.

#### *Contour furrows or pitting*

Contour furrowing or pitting should be installed on approximately 206,400 acres of pasture land. This measure is needed principally in the western portion of the watershed, to increase grass production and decrease runoff from pastures.

#### *Liming and fertilizing*

The application of lime on approximately 220,000 acres and fertilizer on approximately 961,000 acres is needed to obtain proper land use and successful application of soil conservation measures. The need for lime is limited largely to the eastern part of the watershed. Only recently has this need become evident, but tests of some fields are showing that lime should be applied for proper growth of legumes in the rotation. The need for fertilizers in establishing the rotation is more widespread. In most cases fertilizer will also be needed for the establishment of vigorous stands of grasses and legumes on present eroded cropland to be converted to pasture.

#### *Outlets and waterways*

Approximately 10,440 miles of small grassed waterways are needed to provide for the disposition of surplus water at nonerosive velocities into the subwatershed waterways. Natural waterways will be reshaped, gullies will be filled, and suitable mixtures of sod-forming



grasses and adapted legumes will be established. Where fields are terraced, constructed outlets other than natural waterways may be needed in some cases. Fertilizer and barnyard manure will be needed for the establishment of vigorous stands in most cases, and lime should be applied where tests show the need. As a general rule, hay will be harvested from these areas, to prevent smothering of the sod by heavy growth. It will be necessary to give careful attention to the maintenance of vigorous stands, once they are established.

#### *Erosion-control structures*

Approximately 15,960 small erosion-control structures are needed to stabilize terrace outlets and small vegetated waterways. The structures will include concrete, rubble masonry, and earth dams with draw-down tubes, chutes, or flumes.

#### *Diversions*

Approximately 2,940 miles of diversions should be constructed to direct concentrated runoff from above fields and eroded areas in pastures and conduct it to safe disposal in stabilized waterways. In most cases, the channels and side slopes of diversions will be kept in permanent vegetation.

#### *Fencing*

Approximately 2,080 miles of fences are needed for control and distribution of livestock. These will be new fences, and are needed for carrying out proper pasture management.

#### *Irrigation*

The development of supplemental water supplies for crop production attained through pump irrigation from ground aquifers or directly from flowing streams is gaining momentum. Although the area lies in the subhumid rainfall belt, optimum field moisture conditions for maximum crop production during the critical growing season are deficient in most years.

It is estimated that 60,000 acres in the Blue River watershed now receive supplemental irrigation water primarily to assure adequate feed crops for livestock. On the basis of the calculated average annual ground-water supply in the Blue River watershed, the potential acreage having suitable soil and slope conditions for irrigation development approximate 420,000 acres. Farmer demands for technical assistance in developing irrigation wells and water-distribution systems are far beyond the available resources of the Department to supply. Development of this irrigation potential will place new demands for credit and research to guide irrigation efficiencies.

#### *Drainage*

On the loessial plains in the northwestern part of the watershed, numerous shallow field depressions with immature natural drainage result in water pondage in wet seasons that is detrimental to crop production. Many areas along the flood plains of the larger streams and watercourses are in need of drainage for maximum crop and pasture use. It is estimated that approximately 26,000 acres are in need of drainage facilities in the Blue River watershed.

## MEASURES FOR WOODLAND

Following is a description of forestry measures recommended for installation in the watershed to meet conservation, water-flow retardation, and erosion-prevention needs. The quantities indicated include those which will be accomplished by going programs during the 20-year installation period.

*Woodland plantings (excluding shelter belts and windbreaks)*

Woodland planting is recommended on about 28,000 acres in the interest of conservation, water-flow retardation, and soil-erosion prevention. This land recommended for planting consists of small areas along creek and river bottoms which are subject to occasional overflow, small openings in existing stands, and also lands too steep for cultivation. The newly planted areas will be protected from grazing and fire. The present rate of planting will be increased several times.

*Special erosion-control plantings*

About 12,400 acres of this type of planting is recommended to check and prevent gully erosion in upland areas and to restore such lands to their proper use. The primary purpose of these plantings is to eliminate the cause of the gullies and check the further development of those now present by establishment of protective cover of trees and shrubs. In some cases they will be used in combination with structures to stop the headward cutting and deepening of existing large gullies. Following such treatment, these now unproductive areas will yield benefits in the form of posts and other wood products. They will also furnish benefits as wildlife habitat.

*Fire protection*

Fire protection largely in the form of prevention through education and presuppression is provided for the existing woodland and that to be established during the installation period. A very limited amount of this type of measure is now being accomplished under going programs largely in the form of fire-line construction.

*Shelter belts and windbreaks*

The planting of 23,400 acres of field shelter belts is recommended to prevent desiccation of crops and loss of soil moisture from drying winds, reduce wind erosion, stop drifting snow, provide wildlife habitat, and supply posts, poles, fruit, nuts, and other products.

Farmstead windbreak plantings are recommended on 24,700 acres primarily to protect farmsteads and livestock from winter winds and drifting snow. While many farmsteads have limited protection of this type, many need extending or reinforcing and there still remain others in need of complete protection. These plantings will reduce fuel costs and shelter livestock which will increase gains and reduce losses and keep the farmstead free from drifting snow and provide many other benefits.

In the State of Kansas the establishment of shelter belts and windbreaks adjacent to highways will, under certain conditions, entitle lands used this way to an 80-percent reduction in assessed valuation under general property tax. The trees themselves are exempt from taxation.

*Wildlife habitat improvements*

Wildlife habitat will be improved by planting trees and shrubs to create the environment needed by game species which are an important resource of the area. About 12,200 acres are needed for this type of planting. This planting will be done primarily in areas that are unsuitable for cultivation.

*Interplantings*

Most woodlands have been greatly overcut in the past. The more desirable species such as black walnut have been sold, leaving the poorly formed and low-value species. Grazing prevents reproduction, and, in many woodlands, some ground preparation may be necessary before seedlings can become established. To hasten the return of woodlands to a productive condition and to establish more valuable species, interplanting will be necessary on about 28,600 acres. Woodland areas recommended for such treatment will be protected from grazing damage, the cost of which is included in these recommendations.

*Timber-stand improvement*

Repeated cuttings, poor cutting practices, continued grazing, lack of thinning, and other factors have resulted in existing woodlands that are far below their potential productive capacity. To realize maximum benefits, timber-stand improvement is recommended on 81,000 acres. This involves release cuttings, protection of young plantings, thinning, harvesting trees to maintain optimum growth, and similar measures.

## TECHNICAL ASSISTANCE

The amount and cost of technical assistance required to prepare farm plans, to prepare work plans, and to provide technical advice and counsel necessary to apply the land-treatment measures has been calculated as a part of the installation cost of the program.

## EDUCATIONAL ASSISTANCE

The Agricultural Extension Service has offices in every county in the watershed and is providing educational assistance to landowners and operators relative to land and water-resource use and conservation. In order to accelerate the application of needed work on the land, however, there will need to be more effort expended in educational work than is now possible with the existing staff. The program recommends an increase in funds to provide for this.

## ADMINISTRATION OF DIRECT AIDS

An increase in the rate of applying conservation measures on the land will require some increase in funds necessary to administer direct aids. An estimate of the total administration cost of direct aids is calculated and included as a part of total cost.

## RESEARCH AND SOIL SURVEYS

An accelerated research program is needed in the Blue River watershed to guide the recommended program and make possible its most



efficient application. Research will be undertaken on resource-management problems that are particularly significant for the watershed. These include the problem of how to arrest the decline in soil productivity with the least disruption of existing farming systems and with the minimum temporary reduction in farm income. They include the problem of how to adapt irrigation farming to a humid area where heavy rain may follow irrigation and the incentive to irrigate may in some years be small. It will be necessary to appraise the feasibility of the adjustments in farm organization and operation that will be necessary; explore various means of overcoming the serious obstacles likely to be encountered in accomplishing shifts of the extent and nature contemplated; to analyze problems of irrigated agriculture and the impacts of reservoir inundation.

The results of the proposed investigations will not only assist in developing improvement programs adapted to the area, but will also have application on other areas in the Missouri River Basin having similar soils and climate. Data on physical and economic inputs and results are essential for obtaining farmer participation. Such information will also provide a more equitable basis for sharing costs between individual farmers, landlords and tenants, local groups or districts, and State and Federal Governments. The research program will be geared closely to the recommended program of land and water development in order that the results of initial measures may be available for general application as well as for continuously improving the program for the watershed as installation progresses.

The cost estimates are for the first 10 years. At the end of that time the recommendations should be reviewed to determine which, if any, of the lines of research should be continued and if any new problems should be studied.

#### *Conservation and management of farm lands*

*Management and conservation of soil and water.*—A large portion of the Blue River watershed is used for the production of corn and small grains with a relatively small proportion of the acreage being devoted to legumes and grasses. As a result, there is an appreciable loss of water and soil from the uplands during heavy rains. It seems obvious that a greater use of legumes and grasses in the cropping systems would reduce soil and water losses and do a better job of maintaining organic matter and nitrogen in the soil. However, research is needed to determine the proportion of the cropland that should be in grasses and legumes on the different soils for effective conservation of soil and water. Furthermore, it will be necessary to determine the best soil treatments to obtain adequate stands and production of the legumes and grasses. In addition, the contribution of residue management practices, terracing and various cultural practices to effective soil and water conservation will need to be evaluated for the area.

*Economic problems of conservation.*—Soil- and water-management practices as means for controlling or reducing floods must be tested for their economic feasibility. The costs of each practice or combination of practices under conditions in the watershed must be determined and compared with benefits in reducing runoff, soil erosion, and sedimentation.

Obstacles to the adoption of conservation practices must be identified and means found to overcome them. Equitable sharing of costs

and benefits between landlords and tenants need to be developed through research. Study is needed of capital and credit requirements of farmers faced with drastic reorganization of their farms or heavy investments in conservation measures.

When the Government takes over privately owned land in order to use it for reservoir sites, the farmers have to move, agricultural land is taken out of production, and local communities and local governments are disturbed. People within the reservoir area may suffer hardships without compensation while people below the reservoir may receive benefits at no cost to themselves. Research in this field will include an analysis of problems related to the payment of consequential damages, payments in lieu of taxes, land acquisition by Government, local organization in connection with reservoir programs, and relocation of dispossessed farmers.

#### *Forest research*

In the plain areas, trees and shrubs are needed to conserve moisture, to protect lands from floods and stream banks from erosion, to shelter farmsteads and crops from sun and wind, and to shield roads from drifting snow. The timber resource in this watershed is now supplying not more than 5 percent of the local demands for wood products, which is considerably below the potential capacity of the wooded areas. Up to now very little attention has been given to the problems of forestry in this watershed. The proposed program of research will be pointed at solution of these problems. It is also expected to be applicable not only within the boundaries of the Blue River watershed, but also over a considerable area in this general portion of the Missouri River Basin. The purpose of this research program will be to improve the management of shelter belts, farm wood lots, and other wooded areas, and to increase the benefits derived from them.

In order to avoid duplication, research in the Blue River watershed has been coordinated with plans set up for the Salt-Wahoo watershed.

*Forest management.*—Most of the valuable trees in the farm wood lots have disappeared and in their place have appeared inferior species which impair the quality of timber and the productiveness of these areas. Some of the established shelter belts have deteriorated badly and lost effectiveness for protection purposes. Research is needed to develop improved methods of timber use and care of farm wood lots and shelter belts. There is a dire need to develop and improve strains of species which can more successfully stand the climatic conditions in this area and other parts of the plains.

*Forest products.*—A considerable proportion of the existing timber in farm wood lots is made up of species which have little demand or commercial value; the trees are small and of low quality. Research is needed to develop new and better ways of using wood, especially the less desirable species, and improved techniques in cutting timber to reduce waste.

*Forest economics.*—Forest economic data are needed in evaluating contributions of the recommended forestry measures to the agricultural and industrial economy of the watershed. A comprehensive inventory of farm wood lots, windbreaks and shelter belts, and potential planting sites on the farms is necessary to determine the potential development of timbered areas for wood products.



### *Reduction of water runoff and sediment*

*Effect of land use on runoff and erosion.*—It is important to obtain information on the effects of land-use and farming practices on runoff, erosion, and sediment production. The need for information of this nature applies not only to application of the program recommended for the Blue River watershed but with equal force in connection with conservation and flood-control activities in other parts of the Missouri River Basin and throughout the country.

In order to study some of the basic rainfall-runoff relationships, the Soil Conservation Service established a hydrologic experiment station near Hastings, Nebr., in 1938. The station has been in operation since that time. Data on rainfall-runoff relationships associated with various uses of land, farming practices, and conservation measures are obtained at the station for watersheds from 4 to about 3,500 acres in size. A part of the experimental area is in the Blue River watershed and a part in the Republican River watershed.

A large amount of data has already been collected at the Hastings station which will be extremely useful in solution of problems in the Blue River watershed. Research and observations at that location, however, should be intensified. Because of limited funds, soil-loss records and sediment-load records have not been obtained. Such information would add greatly to the completeness and value of the research now under way. There is also an urgent need for thorough analysis and interpretation of the data which have been collected over the past years of operation.

With modest additions in further intensification of effort at the Hastings station, valuable and essential data for guiding application of the Blue River watershed program will be obtained. Information gathered here will be useful also extensively in other parts of Nebraska and Kansas.

*Evaluation of benefits.*—An economic analysis needs to be made of practices and measures suggested for controlling runoff, siltation, and sediment transportation.

Enormous economic values have been built up in certain flood-plain lands. Consequently, severe floods result in heavy economic losses. Hence, there is a need to study the relationship between use of flood plains and flood damage and the economic benefits of various approaches to reduction of flood damage, including direction of economic development in certain parts of the flood plains. The question of zoning flood-plain land should be given careful study.

### *Irrigation development*

*Water, soil, and plant relationships in crop production on irrigated land.*—In common with the Great Plains' section of the Missouri Basin, the Blue River watershed receives highly erratic amounts of rainfall during the growing season. While rainfall is generally adequate for moderate yields of crops, there are often short periods of drought during which crops suffer severely. This situation has brought about a noticeable increase in the irrigated acreage in the Blue River watershed, particularly in the loess plains of Nebraska. There are approximately a thousand irrigation wells in the western portion of the watershed. Research on irrigation methods and soil-management practices are needed to provide recommendations for



the most efficient use of soil and water in the area, since the information from the semiarid regions is not entirely applicable. Irrigation requirements, both seasonal and for peak periods, are crucial problems in the design of farm irrigation systems. The integration of effective irrigation with good conservation is a problem which has scarcely been approached. Adequate and economical equipment for water distribution must have different characteristics than that used in arid areas and therefore needs separate study. The contribution which irrigation can make to a more stable agricultural enterprise, to a more dependable rotation system, and to a higher level of production dictates its careful study as a part of good land and water management.

*Economic problems of irrigation.*—Farmers are not obtaining maximum returns from their available resources. Data regarding costs, returns, labor requirements, yields, and credit needs under irrigation are incomplete. Research will include a careful analysis of various farm organizations adapted to the area, and indicate alternative opportunities in the use of land and water resources. An appraisal of irrigated farm investments, practices, labor requirements, yield, income, and cost expectancies will be included. Similar studies will indicate the cost of pumping water and most efficient methods of distributing water under a system of pump irrigation.

#### *Soil surveys and land classification*

All counties included in the Blue River Basin of Nebraska have basic soil surveys of varying quality. Most of these surveys give excellent general information about soil conditions, though two of the surveys, Gage and Jefferson in Nebraska, are very old and less valuable than those of the other counties in the State. Of the counties in Kansas included in the Blue River watershed, only Riley and Clay have been mapped in any detail. Only a very small part of Clay County lies within the Blue River watershed. Riley County, a much larger proportion of which lies in the Blue River watershed, was mapped in 1906, and this map has little value for farm-planning and soil-management recommendations. All of the basin in Kansas has been covered by reconnaissance conservation surveys made by the Soil Conservation Service. These maps are good for general soil programs, but are inadequate for detailed programs requiring predictions of results on specific tracts of land.

Soil-survey needs for the basin include a generalized soil association map for the entire basin and detailed basic soil surveys for about 2.6 million acres.

During the first 2 years, a generalized soil-association map of the entire Blue River basin should be prepared on a scale of about one-fourth inch equals 1 mile. This map would be prepared from existing soil surveys in Nebraska and from the reconnaissance conservation surveys of Kansas. Some field work would be needed. This map would furnish a reinterpretation of existing soil surveys, making them more useful. Also, it would be useful for outlining areas requiring special attention and for general education programs.

New detailed soil surveys are needed in Gage and Jefferson Counties, Nebr. Detailed soil surveys should also be made in Washington and Marshall Counties, and the western quarter of Pottawatomie County, Kans. These should be completed within 6 years. Riley County, Kans., should be resurveyed within a period of 10 years. Detailed

soil surveys for irrigation are needed for about 162,000 acres mostly in the northwest part of the watershed.

In the review of this report it is expected that the States will indicate the portion of the research and soil-survey costs that will be borne by the States.

TABLE 3.—*Estimated Federal cost of research, soil surveys, and land classification, Blue River watershed, Kansas and Nebraska*

<i>Type of research</i>	<i>Total cost of recommended program</i>
Conservation and management of farm lands:	
Soil and water management.....	<sup>1</sup> \$360, 000
Economic research.....	150, 000
Subtotal.....	510, 000
Forest research:	
Forest management.....	103, 000
Forest products.....	40, 000
Forest economics.....	50, 000
Subtotal.....	193, 000
Reduction of water runoff and sediment:	
Effect of land use on runoff and erosion.....	<sup>2</sup> 195, 000
Evaluation of benefits.....	100, 000
Subtotal.....	295, 000
Irrigation development:	
Water, soil, and plant relationships.....	100, 000
Economic problems.....	50, 000
Subtotal.....	150, 000
Soil survey and land classification.....	505, 000
Total.....	<sup>3</sup> 1, 653, 000

<sup>1</sup> Installation costs of \$10,000.

<sup>2</sup> Includes \$10,000 costs of installations.

<sup>3</sup> The agricultural experiment stations of Kansas and Nebraska expect to provide approximately \$790,000 for cooperative research on these items of research and \$200,000 for soil surveys.

#### MEASURES FOR STABILIZING SMALL WATERCOURSES

The improvements recommended for the stabilization of small watercourses consist of interrelated and interdependent measures which should be installed concurrently on minor watersheds in the proper combination and sequence with land-use and conservation practices on crop, grass, and forest land to attain most effectively and economically the objective of soil and water conservation, and the reduction of land, floodwater, and sediment damages.

The reduction of damage to land, abatement of flood and sediment damages, and continued maintenance and improvement of the land and water resources of the watershed depend upon the proper integration and timeliness of installation of the recommended practices and measures. The recommended program as a whole will increase the intake of water into the soil, retard runoff of water that is not absorbed, and conduct the runoff along its least damaging route to the larger drainage ways.

The land-treatment program recommended for the watershed is designed to develop a favorable condition for infiltration, water

storage, and yield of agricultural products. This favorable soil condition will retard a maximum amount of the rainfall consistent with the use of land for productive purposes and will reduce the rate at which runoff will reach the waterways and tributary streams. On the other hand, it is recognized that the intensity of many rains will exceed infiltration capacities of the soils of the watershed and that runoff of flood-forming proportions will occur even under the most favorable conditions of land use and treatment. It is this excess runoff which must be conducted to the main streams in an orderly manner if erosion damage is to be reduced and downstream inundation and sediment damages abated. Stabilizing measures for small watercourses are needed, therefore, to temporarily retard the damaging runoff and to provide the necessary control of water so that it will pass through the minor waterways and tributary channels with a minimum of damage.

Although the realization of the full benefit of installing measures for stabilizing small watercourses is dependent on the establishment of the program of land-treatment measures, they have been evaluated independently of the land-treatment measures, and only those measures adjudged economically feasible are included in the recommended program.

#### *Recommended measures*

The measures recommended for stabilizing small watercourses have these characteristics:

Their primary purpose is to stabilize minor waterways and tributary streams and to provide for orderly water disposal and sediment control as an essential part of a complete and integrated program of runoff and water-flow retardation and soil-erosion prevention. These stabilizing measures reduce flood and sediment damages, maintain land resources, and protect water-resource developments in the watershed against impairment by sedimentation.

Public benefits from flood and sediment control are dominant, although these measures also produce substantial private benefits and contribute to sound land use.

They frequently involve groups of landowners and operators with common interests in protecting minor watershed units, as well as local agencies of government.

They justify substantial public expenditures in technical and other assistance.

A discussion of the kinds and amounts of measures recommended for stabilizing small watercourses in the Blue River watershed follows:

*Upstream floodwater retarding structures.*—An estimated 912 structures for floodwater-retarding purposes are recommended for installation. These measures, by providing temporary storage, will reduce flood damages caused by runoff in excess of that which can be controlled by the recommended land-use and conservation practices. In addition, installation of these structures will permit more intensive agricultural use of bottom lands. Areas of land now idle or used for pasture because of flood hazards may be utilized for crop production.

Some of these structures will have the added feature of grade stabilization incorporated in the design. This will permit the installation of the complete land-treatment program above sites where grade stabilization is required for efficient and continued effectiveness of the land-treatment measures.



The recommended structures are at sites where the temporary impoundment of water will result in a minor loss in the agricultural production of the land in the reservoir area. The principal type of structure recommended is a small earth-fill dam with an outlet to release water at a fixed and safe rate, and a spillway adapted to site conditions. The structures are planned to temporarily store from  $2\frac{1}{2}$  to 5 inches of runoff without spillway discharge. Drainage areas above the structures range from less than one-half to over 5 square miles.

*Channel improvement.*—Approximately 334 miles of small-stream channel-improvement works are recommended. The improvement works will consist of removing obstructions of stabilizing banks by vegetation and of installing small structures adaptable to the conditions encountered.

Channel improvement is needed in many parts of the watershed to reduce land damage by stream-bank erosion, to reduce damage from sedimentation, and to increase channel efficiency. The channel-improvement works recommended are generally limited to control measures on streams draining less than 100 square miles. Such works will be installed at locations providing protection for cropland, highways, railroads, bridges, utilities, farm buildings, and other high-value improvements.

*Stabilizing and sediment-control structures.*—An estimated 4,635 structures of this type will be required for the control of over-fall, head-cutting gullies, and the stabilization of gradients in upstream channels. The objective is the stabilization of subwatershed drainageways, including road ditches and other artificial channels. The principal types of structures to be installed are drop inlets, chutes, culverts, weir drops, and small retention dams (water-flow-control structures). The structures should be installed in proper sequence and combination with the recommended land-treatment measures. Generally, only a part of the benefits of these structures will accrue to the owner of the land on which they are installed. Therefore, their installation and maintenance will usually involve participation of a group of owners.

*Subwatershed waterway improvement.*—Approximately 2,088 miles of subwatershed waterway improvement will be needed to stabilize and protect natural and artificial channels. These measures include establishment and maintenance of grasses in upland drainageways and artificial channels, generally those which provide water disposal for a group of farms. The improvements consist of excavating, shaping, preparing, and seeding the waterways. Structures needed in conjunction with the vegetative control are included with the recommended stabilizing- and sediment-control structures.

*Diversion ditches and dikes.*—About 22 miles of small diversion ditches and dikes are needed to divert and retard runoff water in order to protect flood-plain developments, eroded areas, and terraced lands. These measures will be used to route runoff water to selected points for safe disposal.

*Floodways.*—Approximately 218 miles of minor floodways are needed to direct damaging flows across flood plains and other flat areas where existing channel capacity is not adequate to discharge these flows. These floodways will consist of excavated channels and related dikes as required.

TABLE 4.—*Total needed program, Blue River watershed*

[Long-term projected prices]

Measure	Unit	Quantity	Installation costs			
			Federal	Non-Federal public	Private	Total
Conservation and improvement measures:						
Crop and grasslands:						
Seeding grasses and legumes	Acre	691, 200	\$4, 147, 200		\$4, 147, 200	\$8, 294, 400
Green-manure and cover crops	do	648, 800	1, 459, 800		1, 459, 800	2, 919, 600
Contour farming practices	do	1, 707, 000				
Terraces	Mile	87, 300	7, 202, 250		5, 892, 750	13, 095, 000
Crop residue management	Acre	2, 893, 000			1, 446, 500	1, 446, 500
Seeding of pastures	do	849, 600	5, 098, 100		5, 098, 100	10, 196, 200
Pasture management	do	1, 915, 700				
Pasture clearing and mowing	do	573, 100	1, 432, 800		1, 432, 800	2, 865, 600
Livestock watering facilities	Number	5, 340	1, 174, 800		961, 200	2, 136, 000
Contour furrows or pitting	Acre	206, 400	206, 400		206, 400	412, 800
Lime	do	220, 000	726, 000		594, 000	1, 320, 000
Fertilizer	do	961, 000	2, 402, 500		2, 402, 500	4, 805, 000
Outlets and waterways	Mile	10, 440	3, 207, 600		2, 138, 400	5, 346, 000
Erosion-control structures	Number	15, 960	3, 830, 400		2, 553, 600	6, 384, 000
Diversions	Mile	2, 940	646, 800		529, 200	1, 176, 000
Fencing	do	2, 080			936, 000	936, 000
Irrigation	Acre	190, 000	1, 900, 000		7, 600, 000	9, 500, 000
Drainage	do	26, 000	104, 000		364, 000	468, 000
Farm wood lots, shelter belts:						
Woodland plantings	do	28, 000	779, 800	\$311, 900	2, 027, 400	3, 119, 100
Special erosion control plantings	do	12, 400	1, 142, 700		761, 800	1, 904, 500
Shelter belts and windbreaks	do	48, 100	1, 417, 000	566, 900	3, 685, 100	5, 669, 000
Wildlife habitat improvements	do	12, 200	135, 700	950, 000	271, 400	1, 357, 100
Interplantings	do	28, 600	281, 900	112, 700	732, 800	1, 127, 400
Timber-stand improvement	do	81, 000	121, 600		486, 300	607, 900
Fire protection	do	231, 600	18, 500	18, 500		37, 000
Technical assistance			18, 055, 800	826, 000		18, 881, 800
Educational assistance			1, 304, 800	429, 600		1, 734, 400
Administration of direct aids			4, 415, 100			4, 415, 100
Research			1, 148, 000			1, 148, 000
Soil surveys			505, 000			505, 000
Measures for stabilizing small water-courses:						
Upstream floodwater retarding structures	Number	912	9, 011, 100	140, 200	861, 000	10, 012, 300
Tributary channel improvement	Mile	334	219, 400	73, 700	20, 400	313, 500
Stabilizing and sediment control structures	Number	4, 635	6, 716, 000	1, 066, 200	612, 800	8, 395, 000
Subwatershed waterway improvement	Mile	2, 088	1, 033, 700	73, 800	615, 300	1, 722, 800
Diversion dikes and ditches	do	22	7, 200	1, 200	4, 700	13, 100
Floodways	do	218	515, 000	206, 600	70, 700	792, 300
Total						
			80, 366, 950	4, 777, 300	47, 912, 150	133, 056, 400

## PROGRAM APPRAISAL

## INCREASED CROP, PASTURE, AND WOODLAND PRODUCTION

With installation of the total needed program, benefits will accrue principally in the form of increased agricultural production. It will result in increased infiltration and stabilization of the soil mantle, resulting in decreased runoff and sedimentation. In the upland areas, sheet erosion and gully erosion will be reduced, while in the bottoms, bank cutting will be reduced, and scour and deposition decreased.

*Cropland*

The installation of the measures in the recommended total needed program for cropland will increase the total production of all major crops. Based on gross value at long-time expected prices per unit, grain crops will be increased by approximately 18 percent, and hay and forage sorghums by 93 percent.



Even though a smaller acreage will be devoted to cropland under the recommended total needed program, increases in per acre yields will result in greater production.

These increases in yields will be due to improved crop rotations, contour cultivation, reduction of sheet erosion and loss of topsoil, conversions of cropland not suited to cropping to other uses, and from expansion of irrigation and improved drainage.

Only those amounts of lime and fertilizer have been included which are needed to establish the proper amounts of legumes and grasses in the rotation; hence, their effect on the production of grain crops will be indirect. The legumes and grasses in the rotations will increase the yields through the addition of organic matter and nitrogen, improved soil structure, tilth, aeration, and drainage. The combined effect of the measures recommended for cropland will increase per acre yields of corn about 6.5 bushels, wheat 4 bushels, oats 5.3 bushels, and hay 0.5 tons.

### *Pasture land*

The measures recommended for pastures are designed to attain a practical maximum yield from all the pasture acreage. The forage yields in terms of animal-unit months of grazing will be increased by about 80 percent. This gross increase in production will be brought about by both an increase in the acreage of land devoted to pasture, and an increase in forage yield per acre. The increased per acre yields will be the result of reseeding depleted stands, ridding pastures of competitive plants, providing additional livestock watering facilities, contour furrowing or pitting some areas, and the application of the recommended pasture management practices. Much of the pasture land is now producing very low yields. Installation of the recommended total needed program will increase per acre forage production by about 45 percent.

It is expected that livestock production will be expanded greatly as the program develops, since total feed crops (feed grains, hay, and pasture) will be increased by about 35 percent. Roughage-consuming livestock will be increased to a greater extent than grain-consuming livestock, as the increase in pasture and hay production will be greater than the increase in grain production.

### *Woodland*

The woodland measures provide for the establishment of about 101,000 acres of woodlot, shelter belt, windbreak, and special plantings for erosion-control and wildlife purposes. They also provide for the treatment of about 81,000 acres of existing stands. Included in the program are costs for fire protection, grazing control, and technical services to aid in the successful installation of the measures.

In addition to benefits realized from reduced runoff and erosion, there are many additional benefits which will accrue from increased productivity of the lands. Most of the lands from which these benefits will be realized are presently unproductive, idle, or producing far below their potential capacities.

The recommended 85,500 acres of shelter belt, windbreak, erosion-control and wood-lot plantings will produce an estimated harvest of 50 fence posts per acre by the end of the fifteenth year following planting, and 15 posts per acre per year thereafter. The increased acreage in woodlands, together with treatment of existing stands, is expected



to produce an increased yield of about 140 board feet of saw timber per acre, per year over an 80-year period, the harvesting of which can start in the fortieth year following planting. In addition to these products for which there is a large demand, other products will be produced, including poles and fuel wood.

Wildlife habitat plantings will add to the numbers of small game in the area, increasing the hunter take as well as providing added recreational opportunities.

Shelter belt and windbreak plantings in addition to producing wood products will protect farm dwellings from the cold winter winds, provide shelter for livestock and feed lots, prevent wind erosion, reduce losses of soil moisture, and desiccation of crops by the hot, drying winds. Road maintenance costs will be reduced by substitution of permanent living snow fence for the temporary type commonly used and by the decreased necessity for snow removal. In addition, there is the increased value of farmsteads and rural homes, due to the protection from the hot summer and cold winter winds, which is reflected in real estate transactions.

#### EFFECT OF PROGRAM ON FLOOD DAMAGE

The reduction of damage to land and of inundation and sediment damage in the watershed depends upon the proper integration and the timeliness of installation of practices and measures recommended in this report. The land-treatment phase of the program is formulated to develop the most favorable conditions for infiltration and water storage. This favorable soil condition will permit maximum retention of rainfall and will reduce the rate at which runoff will reach the waterways and tributary streams. The flow of water which is not absorbed will be collected and conducted off the land through stabilized waterways to the larger drainage ways with a minimum of damage. Where practicable upstream floodwater-detention structures will further retard the flow of water which is not retained on the land. Other measures, such as floodways, will reduce damages from bank erosion and scour of flood plains where existing channel capacity is not adequate to handle damaging flows.

Evaluation of the effects of the installation and maintenance of the total needed program indicates that land damages will be reduced by 51 percent; inundation damages by 39 percent; and sediment damages by 48 percent. Additional benefits will accrue in the form of prevention of sediment damage to reservoirs proposed by the Corps of Engineers.

#### OTHER BENEFITS

A principal objective of the program as a whole is the conservation and improvement in productivity of the land resources of the watershed. An additional benefit to be realized from the program of upstream retarding structures is the change in land use which will be brought about immediately below some sites. The net return from approximately 12,000 acres of such land which is now the lowest income-producing land in the watershed will be increased by an estimated \$343,000 annually.

## ECONOMIC JUSTIFICATION

Economic justification calculated as costs and benefits are included in this report for those measures contributing to flood control. These measures are shown in table 5 under the headings: "I. Land treatment measures in aid of flood control" and "II. Stabilizing small watercourses." The ratio of benefits to costs is calculated separately for these two groups of measures as follows:

*Land treatment measures*

This group includes the crop, pasture, and woodland conservation measures.

It is estimated that the installation and maintenance of these measures that contribute to waterflow retardation and soil erosion prevention, will result in the following average annual benefits:

Increased production of crop, pasture, and forest land-----	\$22, 321, 700
Reduction in inundation and sediment damage-----	1, 397, 300
Reduction of sediment damage to reservoirs proposed by the Corps of Engineers-----	54, 900
Total average annual benefits-----	23, 773, 900

The annual operation and maintenance cost is \$4,809,300. Except for a portion of the increased cost of forest-fire protection, all of this is borne by non-Federal funds. The average annual value of the total cost of these measures is \$6,596,800.<sup>1</sup>

The ratio of benefits to cost is 3.6 to 1.

*Measures for stabilizing small watercourses*

The upstream floodwater-retarding structures to be installed in the headwaters of tributary streams are designed to provide temporary storage for runoff. They will reduce both agricultural and nonagricultural damages from inundation and will protect flood-plain lands immediately downstream from the site to the extent that they may be put to a more intensive use.

The construction of stabilizing and sediment-control structures and of diversion ditches and dikes in conjunction with the improvement of subwatershed waterways will reduce erosion damage from gullies; reduce the depreciation of watershed lands which accompanies gully erosion in small watersheds; reduce sediment damage; and insure the continued effectiveness of the upland treatment measures. Since many of the needed upland measures are dependent on the above measures for permanent effectiveness there is a conservation benefit attributable to the subwatershed waterway-stabilizing program. Increased intensity of land use will be possible below many of the proposed diversions.

The construction of floodways in minor drainage ways and improvement of small stream channels by stabilizing the banks, removing obstructions, and installing other protective measures will bring about a reduction in stream-bank erosion damage, flood-plain scour damage, sediment damage, road and bridge damage, and damage to reservoirs proposed by the Corps of Engineers.

The recommended measures installed on land not under the jurisdiction of the Federal Government are to be operated and maintained

<sup>1</sup> The average annual equivalent of the installation costs is computed by use of a 2½ percent interest rate for Federal and non-Federal installation costs and a 4 percent interest rate for private installation costs. This annual equivalent plus the operation and maintenance costs result in the total average annual cost.

by State and local agencies under arrangements acceptable to the Secretary of Agriculture, and installation in any area will not be commenced until such arrangements have been made. The boundaries of any such area shall be determined by the Secretary.

The average annual cost of the stabilizing program includes the annual equivalent of the installation cost, operation and maintenance cost, and the cost of flowage rights and replacement where applicable. This annual cost is \$1,115,200. Of this, \$551,200 is operating and maintenance cost and the cost of replacement, and will be borne by non-Federal funds.

It is estimated that the installation and maintenance of these measures will result in the following average annual benefits:

Reduction in land damage.....	\$36, 800
Reduction in damage due to inundation.....	1, 117, 300
Reduction in sediment damage.....	57, 100
Reduction of sediment damage to proposed Army engineers' reservoirs.....	5, 500
Conservation benefit.....	1, 803, 000
Increased production on bottom land.....	343, 200
Total average annual benefit.....	3, 362, 900

The ratio of benefit to cost is 3 to 1.

#### RECOMMENDED ACCELERATED PROGRAM

To carry out the total needed program in the Blue River watershed within a 20-year period will require an acceleration of work above the current program and will require the installation of measures not now included in the current program of the Department of Agriculture.

Table 5 sets forth the additional items of work and estimated costs that will be required on a project basis in addition to current programs to carry out the job in 20 years.



TABLE 5.—Recommended accelerated program, Blue River watershed

[Long-term projected prices]

Item	Unit	Quantity	Installation costs			
			Federal	Non-Federal public	Private	Total
CONSERVATION AND IMPROVEMENT MEASURES						
Crop and grass land:						
Seeding grasses and legumes	Acre	468,200	\$2,809,200		\$2,809,200	\$5,618,400
Green manure and cover crops	do	523,480	1,177,800		1,177,800	2,355,600
Contour farming practices	do	771,000				
Terraces	Mile	59,840	4,936,800		4,039,200	8,976,000
Crop-residue management	Acre	1,158,380			579,200	579,200
Seeding of pastures	do	731,760	4,390,100		4,390,100	8,780,200
Pasture management	do	1,485,500				
Pasture clearing and mowing	do	456,220	1,140,500		1,140,500	2,281,000
Livestock watering facilities	Number	680	149,600		122,400	272,000
Contour furrows or pitting	Acre	196,540	196,500		196,500	393,000
Lime	do	140,000	462,000		378,000	840,000
Fertilizer	do	561,000	1,402,500		1,402,500	2,805,000
Outlets and waterways	Mile	6,840	2,093,040		1,395,360	3,488,400
Erosion-control structures	Number	12,580	3,019,200		2,012,800	5,032,000
Diversions	Mile	1,680	369,600		302,400	672,000
Fencing	do	1,620			729,000	729,000
Irrigation	Acre	50,000	500,000		2,000,000	2,500,000
Drainage	do	20,000	80,000		280,000	360,000
Subtotal			22,726,840		22,954,960	45,681,800
Farm wood lots, shelter belts:						
Woodland plantings	Acre	27,666	769,500	\$307,800	2,000,600	3,077,900
Special erosion-control plantings	do	12,203	1,127,800		751,400	1,879,200
Timber stand improvement	do	81,000	121,600		486,300	607,900
Wildlife habitat improvement	do	10,500	116,800	817,300	233,500	1,167,600
Shelter belts and wind breaks	do	44,200	1,301,500	520,600	3,383,900	5,206,000
Fire protection	do	231,600	18,500	18,500		37,000
Interplantings	do	28,600	281,900	112,700	732,800	1,127,400
Subtotal			3,737,600	1,776,900	7,588,500	13,103,000
Technical assistance						
Educational assistance			8,032,800	820,600		8,853,400
Administraton of direct aids			978,300	302,700		1,281,000
Research			2,072,500			2,072,500
Soil surveys			1,148,000			1,148,000
			505,000			505,000
Subtotal			12,736,600	1,123,300		13,859,900
MEASURES FOR STABILIZING SMALL WATERCOURSES						
Upstream floodwater retarding structures						
Tributary channel improvement	Number	912	9,011,100	140,200	861,000	10,012,300
Stabilizing and sediment control structures	Mile	334	219,400	73,700	20,400	313,500
Subwatershed waterway improvement	Number	4,635	6,716,000	1,066,200	612,800	8,395,000
Diversion dikes and ditches	Mile	2,088	1,033,700	73,800	615,300	1,722,800
Floodways	do	22	7,200	1,200	4,700	13,100
	do	218	515,000	206,600	70,700	792,300
Subtotal			17,502,400	1,561,700	2,184,900	21,249,000
Total			56,703,440	4,461,900	32,728,360	93,893,700



### SECTION III

## UPPER SOUTH PLATTE WATERSHED (COLORADO AND WYOMING)

### C O N T E N T S

---

	Page
Purpose of the program.....	119
Description of the watershed.....	120
Present status of economic development.....	121
Desirable pattern of permanent land use.....	125
Watershed problems.....	126
Current status of work.....	129
Total needed program.....	130
Program appraisal.....	149
Recommended accelerated program.....	151

### LIST OF TABLES

Table

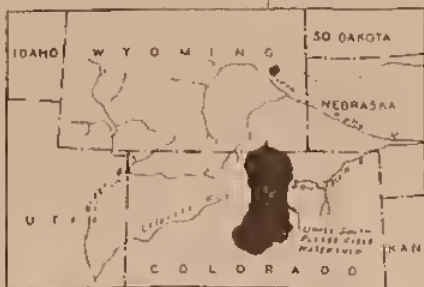
1. Estimated future average annual damage, upper South Platte watershed (long-term projected prices).....	128
2. Total needed program, upper South Platte watershed (long-term price projection).....	131
3. Estimated Federal cost of research and soil surveys, upper South Platte watershed.....	146
4. Recommended accelerated program, upper South Platte watershed (long-term price projection).....	151







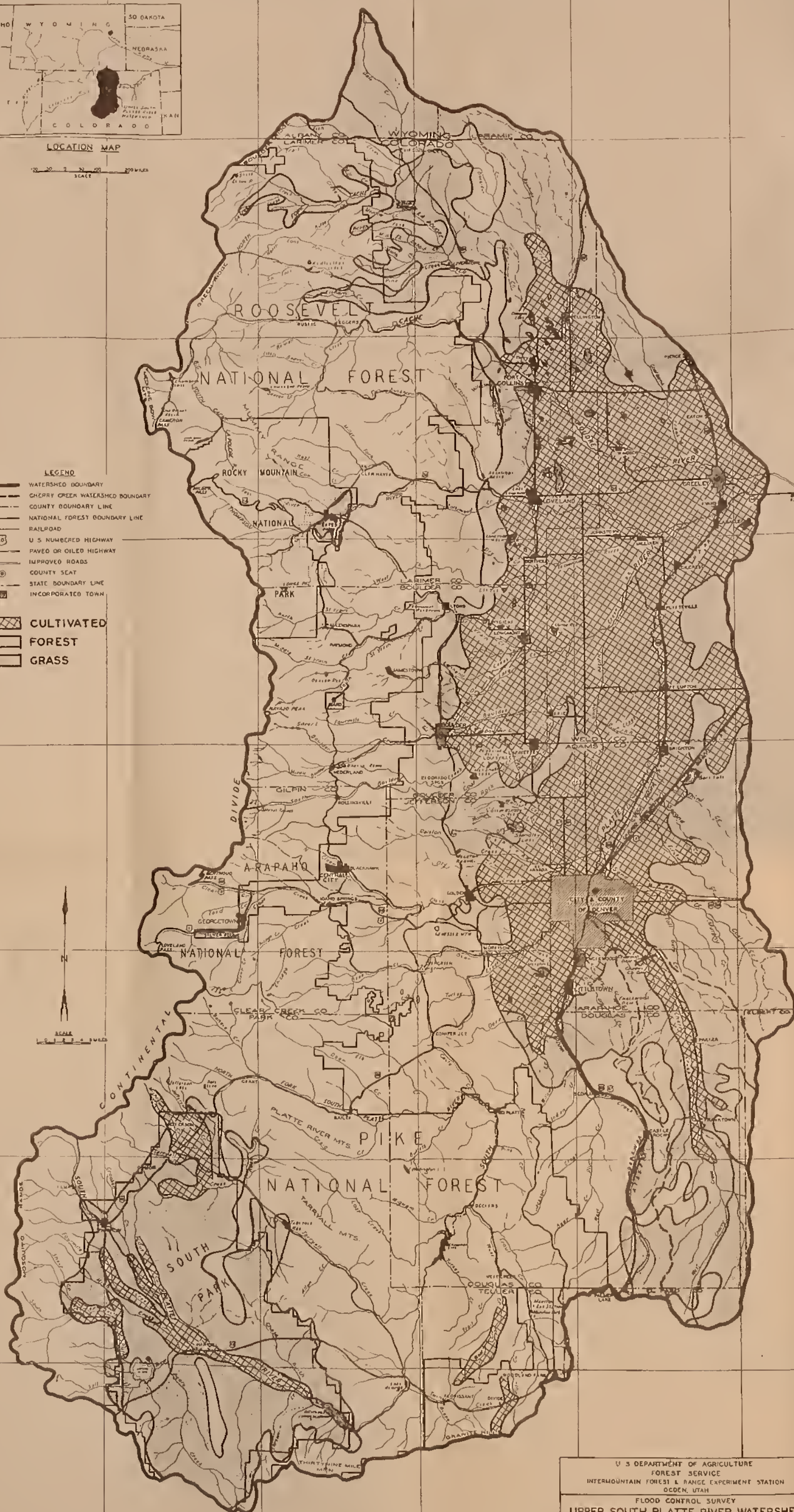




LOCATION MAP

SCALE 0 10 20 30 MILES

- LEGEND**
- WATERSHED BOUNDARY
  - CHERRY CREEK WATERSHED BOUNDARY
  - COUNTY BOUNDARY LINE
  - NATIONAL FOREST BOUNDARY LINE
  - RAILROAD
  - U S NUMBERED HIGHWAY
  - PAVED OR OILED HIGHWAY
  - IMPROVED ROADS
  - COUNTY SEAT
  - STATE BOUNDARY LINE
  - INCORPORATED TOWN
- CULTIVATED**
- FOREST**
- GRASS**



NOTE: THIS MAP IS GENERALIZED

U S DEPARTMENT OF AGRICULTURE FOREST SERVICE INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION OGDEN, UTAH	
FLOOD CONTROL SURVEY UPPER SOUTH PLATTE RIVER WATERSHED (ABOVE KERSEY, COLORADO)	
<b>VEGETATIVE COVER</b>	
SUBMITTED JAA	APPROVED HLL
COMPILED BY T	MAP NO.
TRACED BY JET	APPENDIX NO.
CHECKED BY JAS	



### SECTION III

## UPPER SOUTH PLATTE WATERSHED (COLORADO AND WYOMING)

### FOREWORD

The upper South Platte watershed has been selected for incorporation in this supplement to House Document 373, Eighty-first Congress, first session, for several reasons. Large portions of the area have suffered critical and fundamental land resource damage and deterioration is continuing. Important values are at stake in water, agriculture, timber, recreation, wildlife, livestock production, and industry. The lands have a high recovery potential and the conservation measures proposed will yield abundant returns. A variety of conditions are involved, from the water-yielding lands of the high mountains to the water-using country below. Past misuse and deterioration of the mountain lands have increased the hazards from floods, adversely affected the supply of water for irrigation, industrial and domestic purposes, impaired forest and range productivity, and detracted from recreational assets. Thus efficient management and wise use of the natural resources play an important role in development and strength of the local and regional economy.

The proposed program requires close integration and correlation of efforts between the Department of Agriculture, other Federal agencies, the participating State agencies, and the farmers who will carry a large share of the responsibilities in this undertaking.

The recommended program embraces the accelerated activity which, when coupled with current programs, will meet the total estimated need for the development, management, and use of the land, water, and forest resources of the watershed in a 20-year period.

The proposed procedure in applying the recommended accelerated program is to divide the watershed into relatively small work areas, frequently the size of a minor tributary drainage. In the beginning, the work would be concentrated in a few of these areas so as to accumulate the benefits of interrelated measures on each such area as rapidly as possible and to demonstrate the effectiveness of the program. An orderly schedule would be followed in initiating work in additional areas so as to complete the entire program within the 20-year installation period.

### PURPOSE OF THE PROGRAM

1. To coordinate agricultural development and increased production with the conservation of the natural resources.
2. To correct poor land management practices wherever they are occurring.
3. To establish watershed practices which will minimize erosion and reduce flood peaks, stabilize stream flows, and increase the usability of water for many vital purposes.

4. To help reduce loss of life and damage to property from floods.
5. To improve the basin for future development by scientific appraisal of accomplishment, reliable resource inventories, and more research.
6. To complete the installation of the needed program for the development, management, and use of the agricultural resources within 20 years.

## DESCRIPTION OF THE WATERSHED

### LOCATION AND SIZE

The upper South Platte watershed, consisting of 5,863,000 acres, includes the entire drainage area of the South Platte River above Kersey, Colo. Geographically it is situated in north-central Colorado with a small portion extending into southern Wyoming. The main stem rises near the Continental Divide and flows in a general north-easterly direction for a distance of approximately 210 miles to a point between Kersey and Greeley, Colo. The principal tributaries are the Cache la Poudre River, Thompson River, St. Vrain Creek, Boulder Creek, Clear Creek, Bear Creek, North Fork of the South Platte, and Cherry Creek. (See map.)

### PHYSICAL CHARACTERISTICS

The watershed can be divided into two parts. The western two-thirds of the watershed is in the mountains, varying in elevation from 8,000 to 14,000 feet. The topography is broken by deep canyons, high mountain ridges, and steep slopes. The eastern third is in the foothills and plains, and varies in elevation from 4,000 to 8,000 feet. The topography here is less rugged, with shallower drainages, lower ridges, and rolling hills. Much of this part of the watershed is nearly level.

### CLIMATE

There are wide variations of climate between the mountainous portion and the plains. However, low humidity, abundant sunshine, and high winds are characteristic of the entire watershed. The average annual precipitation in the mountains varies from 15 to 30 inches. Most of the precipitation falls as snow which may not disappear from some of the sheltered slopes until late spring or early summer. The annual precipitation increases with elevation and the higher reaches of the watershed yield more water per acre than the lower areas. In the plains, rainfall is generally lower and the temperature higher than in the mountains. Much of the rain during the summer months comes in heavy downpours. The growing season extends for about 150 days.

### SOILS

Because of extremes of elevation, parent material, relief, and climate, the soils vary widely as between the mountains and the plains.

In the mountains weathered granites, schists, and related rocks are the principal parent materials. The soils are generally coarse textured, and light in color. Much of the soil is rocky. Because of this and the relatively short growing season, the mountain soils are primarily adapted to trees, brush, and grass.

In the foothills the soils are mostly of sandstone, shale, or limestone origin; they vary greatly in texture, stoniness, and depth, being finer, deeper, and richer along drainage bottoms than on the slopes. They too are primarily suited only for trees, brush, and grass.

In the plains and South Park the soils are mostly of loess and alluvium; deep, medium-textured soils, brown in color and low in organic matter and nitrogen, dominate. Under irrigation, the smoother areas are generally well suited to crop production.

#### NATURAL VEGETATION

Native trees, shrubs, and grasses cover most of the mountain and foothill lands. Above the timber line there is a relatively narrow belt of low shrubs and grasses which are characteristic alpine types. Extending down the slopes are mixed stands of Engelmann's spruce, alpine fir, and lodgepole pine which are gradually replaced at the lower elevations by ponderosa pine and Douglas fir. Grassy park-like openings are found throughout most of the timbered areas but they are more frequent and of larger size in the ponderosa pine zone. The largest of these is the area of open grass and meadow lands known as South Park. At the foot of the mountains and throughout the foothills, the vegetation is principally brush and grass with irregular stringers of trees along the stream banks.

The lands under cultivation are located mainly in the drainage bottoms and in the low rolling hills of the plains. Intermingled with the croplands are moderately steep slopes and narrow ridge tops covered with native brush and grass, and small patches of broadleaf trees along the stream courses.

#### PRESENT STATUS OF ECONOMIC DEVELOPMENT

##### POPULATION

Since the initial settlement in 1860 there has been a steady increase of the population residing in the watershed until it is now estimated to total approximately 617,000 people. Denver is the principal city and combined with the surrounding metropolitan developments has a population of 563,000 people. Other cities and towns include Greeley, Fort Collins, Loveland, Longmont, LaFayette, Boulder, Golden, Arvada, Englewood, Littleton, and Idaho Springs. The density of population in the plains-foothill area, exclusive of Denver and surrounding metropolitan developments, is about 35 persons per square mile. The density in the mountains is five persons per square mile.

##### OWNERSHIP PATTERN

The division of ownership, considering the entire watershed as a whole, is approximately 60 percent in private holdings, 4 percent in State, county, and municipal holdings, and 36 percent in Federal holdings. The heaviest concentration of private ownership is in the plains where 93 percent is private lands, 3 percent State, county, and municipal lands, and 4 percent Federal lands. A different pattern of ownership exists in the mountains where 33 percent is private lands, 4 percent is State, county, and municipal lands, and 63 percent is Federal lands. A census of the 7,800 farm operators in the watershed



shows 29 percent are tenants, 56 percent are full owners, 14 percent are part owners, and 1 percent are managers. The national forests, which are under the administration of the Department of Agriculture, comprise 84 percent of the Federal ownership; public domain and national parks under the administration of the Department of Interior constitute most of the remaining 16 percent.

#### PRESENT LAND USE

##### *Cropland*

When the early pioneers began to settle in this country, the principal agricultural pursuit was the raising of range livestock supplemented with limited farmings. As the population increased, more attention has been given to the production of cultivated crops. At present, cropland in the watershed is estimated at 1,228,000 acres, of which 723,000 acres are irrigated. The principal farm crops are sugar beets, alfalfa, potatoes, barley, vegetables, wheat, beans, and corn. The value of agricultural products in 1945 was \$43,000,000. It would be considerably greater in terms of present prices. The 59 percent of the cultivated lands in irrigation produce about 88 percent of the gross value of the farm crops.

The Denver-Fort Collins-Greeley locality is considered one of the most highly developed irrigated areas in the United States. All irrigation enterprises in the South Platte, previous to the Colorado-Big Thompson project, were developed with private capital either by the landowners, by cooperative stock companies, or by irrigation districts. About 500,000 acres of intensively developed irrigated land is situated along stream channels. Of this a considerable acreage is vulnerable to serious damages from spring and summer floods.

Much of the cultivated land in the foothills adjoining the plains is located on steep slopes and is a source of excessive amounts of runoff and sediment. Floodwater and sediment from these and other cultivated lands cause considerable damage to areas which are situated below them.

##### *Grassland*

Since World War I, an expansion of cultivation has caused a substantial reduction in the acreage of grassland in the plains. This decline was checked and even reversed temporarily in the 1920's and 1930's during periods of low farm prices and severe drought. The downward trend was resumed when favorable conditions prevailed. The areas converted to cropland generally included the most productive grasslands. As a result the 882,000 acres remaining in grass are primarily the poorer grazing land.

These changes in land use have brought about the replacement of large livestock operations with ownership of a few head of livestock by most of the 7,800 farm operators. Some of the operators produce on their farms most, if not all, of the livestock food they require while others are largely dependent upon the public and leased grassland and forest range for livestock food. The loss in production of meat and wool from the conversion of grassland is considerable more than offset by the increase in forage production on irrigated cropland and pasture.

The long and continuous use by livestock has adversely affected the productive capacity of the grassland. In many places the heavy

concentration of livestock and close grazing have reduced the density of the grass and broken the sod, thereby causing serious sheet and gully erosion. The repeated trampling by livestock also compacts the surface of the soil and reduces its capacity to absorb water.

### *Forest and forest range lands*

The forest and forest range lands, totaling 3,309,000 acres, have played and will continue to play an important role in the development of the watershed. These lands are a vital source of water supply. They also provide timber for lumber and other wood products, forage for livestock, habitat for wildlife, and recreational attractions.

Most of the water, which is veritably the lifeblood of the watershed, comes from the snow and rain that fall on these lands. Some 85 percent of the 1,500,000 acre-feet of water that runs off the lands draining into the upper South Platte above Kersey, Colo., originates in the forests and forest ranges. A good cover of trees and shrubs, with a layer of litter on the ground, can sustain the flow of clear water. It delays the melting of snow, retards surface runoff, reduces the height and frequency of floods, holds the soil in place, and enables it to absorb water readily. Similar results can be obtained from grass cover in good, healthy condition. These functions have been seriously impaired on some of the forest and forest range lands by the destructive effects of fire, overcutting, excessive grazing, and other causes.

The 1,861,000 acres of commercial timberlands are now supplying approximately 13,000,000 board feet of timber annually for lumber and other wood products. This cut could be increased to approximately 21,000,000 board feet with the construction of roads to inaccessible stands. Eventually, with the reforestation of denuded or partially stocked lands, and the application of more intensive management practices, the sustained yield should approach 75,000,000 board feet annually.

The forest range lands total approximately 2,170,000 acres, of which more than 500,000 acres are located in the South Park area. They consist of openings of brush, weeds, and grass in and adjacent to forested lands, stringers of forage plants along the mountain streams, and mountain meadows at the higher elevations. Some of the nearby livestock operations use the available forage to supplement what is produced at home or obtainable elsewhere. The continual heavy use for many years has created a need for extensive remedial action on some of the range lands. Overuse is reflected not only in the deterioration of the range cover but also in the impairment of watershed functions of the land.

Forest recreation is increasing year by year. The growing population of Denver and other parts of the watershed resides only a few miles from the mountains. Summer recreation varies from a day's drive and a picnic lunch to camping for a few days or a few weeks' stay at a commercial resort. Many families have summer homes where they stay several months. In 1950 approximately 3,900,000 people from all States in the Union and from many foreign countries enjoyed the various recreational attractions. There has been a steady growth also in winter sports. The demands for necessary facilities are requiring extensive developments, particularly on the national forests. Unfortunately, the present facilities are inadequate



to meet the basic health and sanitation needs for either summer or winter recreational use.

The hilly and mountainous lands are the natural habitat for deer, elk, bear, and other wildlife. The mountain streams are exceptionally suitable for fish. Much of the plains area also furnishes food and shelter for game animals and birds. Hunting within the watershed is enjoyed by approximately 8,500 hunters and fishing by 66,000 fishermen annually. Careful management is required to maintain wildlife populations and to keep the numbers of game animals and fish in balance with the available food supply.

#### *Miscellaneous lands*

The remainder of the watershed, approximately 444,000 acres, comprises barren mountain peaks, areas covered by water, and lands used for roads, cities, and industrial development.

### THE CONTROL AND USE OF THE WATER RESOURCE

Much of the economic development in the watershed rests upon the careful use and husbanding of the water resource. Before the turn of the century small transmountain diversions from the Colorado, Laramie, and North Platte Rivers were constructed to bring under irrigation additional acreage in the Pierce-Eton area of the South Platte watershed. Prior to 1940 local interests had constructed 723 storage reservoirs with a total capacity of approximately 1,394,000 acre-feet. In 1943, 1½ million acre-feet were used primarily for irrigation.

Some of the farmers have found it necessary to resort to pumping from wells in order to obtain a more adequate water supply. Approximately 240,000 acre-feet are now being pumped annually. Experience in other parts of the country, where heavy pumping has seriously lowered the ground-water level, indicates that this may become a serious problem.

The city of Denver obtains a large share of its water supply from the South Platte River. It has constructed, or has an interest in, seven reservoirs with a total capacity of almost 229,000 acre-feet. In 1938, the total cost of the Denver water system was calculated at \$42,184,000; on December 31, 1950, it was \$51,818,000. The investment is steadily increasing.

The Department of the Interior is completing the Colorado-Big Thompson project, designed to increase the water supply for use in and adjacent to this watershed. It involves the diversion of 265,000 acre-feet annually from the Colorado River through the Continental Divide by tunnel to the South Platte watershed. The cost of this project including the facilities for hydroelectric power will total more than \$120 million. Other projects, including the Blue-South Platte, are under consideration and in various stages of planning.

### OTHER ECONOMIC DEVELOPMENT

Manufacturing, centered largely around Denver, has become the major activity in the watershed and is steadily increasing. In 1939, the value which was added to products by processing was calculated to be \$57 million; in 1948, it had increased to \$170 million. This has been partly the cause of and partly the result of the steady increase in



population, the growing network of highways, railroads, and air transportation facilities, and the construction of additional water and power developments. The value of all properties within the watershed is conservatively estimated at \$2,320,028,000. This general locality is becoming increasingly important also as a military center in the current national defense effort.

Mining is the oldest industry in the watershed. It was the lure of gold, silver, lead, and other precious metals that first attracted substantial numbers of people to this part of the country. While mining has undergone major cyclic changes, it still ranks third among the major enterprises. At present the mined coal has a slightly higher value than the metals. In 1946 the estimated value of all minerals was \$5,400,000.

### DESIRABLE PATTERN OF PERMANENT LAND USE

To achieve sound economic development in the watershed, the pattern of land use should be consistent with the land capabilities and should be designed to protect, maintain, and improve the land resources. The application of these fundamental principles sustains the productive capacity of the land, the high yields of usable water from the mountains, and a continuous supply of resources for local and regional needs. It also reduces erosion and peak flows of floodwaters.

#### CROPLAND

Now under cultivation are marginal croplands which possess such characteristics as shallow soils, steep slopes, excessive wetness, and rock outcrops. These lands can be most effectively utilized by conversion to permanent vegetation. In order to increase and maintain the productive capacity of lands which remain in cultivation, such measures as leveling, improvements in irrigation practices, terracing, contour farming, strip cropping, rotational use of irrigated pasture, and other adaptable measures should be installed in various combinations as needed.

#### GRASSLAND

In the plains the present grasslands, with few exceptions, are best adapted to a grass cover. They are located principally in the rolling hills and possess thin, poor-quality soils. Grasses and other native plants on these lands not only furnish forage for livestock but also prevent the movement of soil from the slopes and ridge tops and reduce the surface runoff from heavy rains. Grazing by livestock should be conservative so as to increase the density of the vegetative cover, stimulate plant growth, and restore more of the valuable forage plants. Artificial reseeding will be necessary in some areas to insure recovery of deteriorated cover. Stock-watering facilities, fences, and other measures should be installed for proper use of the available forage.

#### FOREST AND FOREST RANGE LAND

The lands in the mountainous portion of the watershed should retain their native cover of trees, shrubs, and grasses. They are chiefly valuable for watershed purposes, but the resources produced on the

lands can also contribute greatly to the local economy in other ways. Careful management and conservative use of these land resources are required to obtain maximum benefits and assure permanent productivity. The multiple uses of the land must be closely correlated and balanced in order to prevent serious damage to one or more of the resources. This objective can be accomplished on forest lands through such measures as periodic selective cutting of merchantable timber, removal of defective and diseased trees, reforestation of denuded areas, thinning of overcrowded, stagnant stands of young trees, adequate fire protection, and judicious development of recreational assets. In areas suitable for grazing, recommendations similar to those prescribed for grassland are generally applicable.

### WATERSHED PROBLEMS

The rate and degree of program accomplishment will be significantly affected by the complexity of the landownership pattern, particularly in the plains. Size of holdings and types of operations create economic problems in seeking adjustments and improvements in land use. The attitude of the private landowners and operators will largely determine the extent of their participation in the application of the recommended measures. The primary role of the Government with respect to private lands will be to offer the owners and operators educational and direct aid, technical services, and credit. It is recognized that cutting and other practices on private forest lands should be subject to public regulation to check forest destruction and deterioration and to keep the land reasonably productive. Some of the private lands in the mountains and foothills present such difficult problems or are so situated with respect to public lands that public ownership is deemed to be the ultimate solution.

The processes of restoring and rehabilitating natural resources are slow and gradual. Improved techniques are needed to increase the effectiveness of some of the proposed remedial measures. Sufficient basic data are not available to determine the most feasible solutions to some of the complex problems. Additional research is necessary to gain further knowledge of the interrelationship of the factors that affect the development, management, and use of the natural resources.

### FLOOD AND EROSION PROBLEMS

Flood problems in the watershed have steadily become more acute since settlement began in 1859. Many of the town sites were chosen near the main stream or tributary channels because of availability of water, fuel, and fertile soil. As settlement progressed, roads and railroads also became established along the waterways. This continuous development has resulted in heavy concentrations of improvements and people near the stream bottoms. When floods occur, the waters rush down the steep restricted mountain channels onto the plains, overtopping the channels and inundating valuable farm lands and urban property.

Two distinct types of storms occur in the lower part of the watershed. General storms over large areas of the watershed result in high sustained discharges in the main stream and major tributaries. Since 1860 more than 10 major floods are known to have occurred from this

cause. The cloudburst type of storm produces relatively low volumes of runoff, but high peak flows which usually recede in a few hours. Nearly every year, storms of this type occur in the foothills and mountains, causing floods and heavy damages to nearby towns and other improvements. Flash floods with high peak flows generally carry large amounts of debris.

More cloudburst floods have been experienced in Bear Creek than any other tributary of the South Platte River. Since 1878 some 15 floods have caused millions of dollars in damages and the loss of 45 lives.

The flood of August 3, 1951, from Buckhorn Creek near Loveland, which destroyed the Buckhorn Dam and drowned seven persons, is a vivid example of the flood threat that exists on many tributaries.

#### EFFECTS OF PAST AND PRESENT LAND-USE PRACTICES

Surveys reveal that the vegetation on much of the forest and forest range lands is not in satisfactory condition. Fire, overgrazing, and poor timber-cutting practices have been the major contributors to this situation. In the mountains 23 percent of the vegetative cover is estimated to be in poor, 32 percent is in fair, 39 percent is in good condition, and 6 percent is unclassified. In the foothills 47 percent is in poor, 44 percent is in fair, and 9 percent is in good condition. Deterioration of the plant cover has increased both the amount and rapidity of surface runoff, decreased soil moisture available for plant growth and caused accelerated erosion.

#### EXTENT OF EROSION

Portions of the mountain and foothill lands where plant cover has deteriorated have suffered serious soil losses by moderate and severe sheet and gully erosion. These damages have occurred in the open ponderosa pine, brush, and grass areas, chiefly where grazing has been too heavy. In the plains moderate sheet and gully erosion is widespread on lands where cultivation has not been in conformance with good conservation practices and where the grass cover has been badly depleted.

#### SEDIMENTATION

The deposition of large quantities of sediment along the stream channels, in the reservoirs, in the irrigation distribution systems, and on the farm lands, creates serious obstacles in the development of the watershed. Silt in water decreases its usability for irrigation, industrial, and domestic purposes, and increases the costs of securing adequate supplies for such uses. The principal contributors of sediment in the forest and range areas are the lands with little vegetation, while in the farming areas they are the lands being cultivated without regard to proven soil-conservation practices. The current situation is exemplified by the fact that 95 percent of the sediment comes from sheet and gully erosion and only 5 percent from cutting of stream banks. The annual rate of erosion from the mountainous portion of the watershed is 0.07 acre-foot per square mile, from the foothills 0.25 acre-foot per square mile, and from the plains 0.38 acre-foot per square mile.



Early placer mining in many of the mountain valleys, the gold dredges currently operating in the South Park area, and mill tailings from lode mining in the Clear, Boulder, and Left Hand Creeks have contributed greatly to the sedimentation problem. Large quantities of sediment have also come from irrigation canals, such as the North Poudre division, which have been constructed on too steep a gradient.

Approximately 1,870 acre-feet of storage is lost annually by sedimentation of existing reservoirs, whose total capacity is estimated at 1,394,000 acre-feet. In addition, the deposition of large quantities of silt in diversion ditches and irrigation channels is reducing the effectiveness of the water distribution systems and increasing the costs of operation.

#### CHARACTER AND EXTENT OF FLOOD DAMAGES

The estimated future annual direct floodwater and sediment damages are shown in table 1. In addition, there are numerous losses which are not evaluated in monetary terms. Among the most evident forms are loss of life, disruption of normal activities in the flooded area, loss of wages, decrease in land values, and inconveniences to travelers.

TABLE 1.—*Estimated future average annual damage, upper South Platte watershed*

[Long-term projected prices]		Average annual damage
Type of damage		
Land damage	-----	\$178, 500
Inundation damage:		
Agricultural	-----	\$174, 900
Nonagricultural	-----	241, 900
		416, 800
Sediment damage	-----	603, 200
Total	-----	1, 198, 500

A brief explanation of the direct damages included in table 1 is given below.

#### *Land damage*

This type of damage includes losses from cutting of stream banks, scouring, deposition of infertile overwash, and gully erosion.

#### *Inundation damage*

*Agricultural.*—Agricultural damages consist of damages to crops and livestock; to farm improvements, including farm buildings and their content, fences, wells, and farm equipment; and to irrigation facilities. Crop and livestock losses are the heaviest of the agricultural damages.

*Nonagricultural.*—Nonagricultural damages consist chiefly of damages to roads and bridges and to residential and commercial buildings (including their content). Also included is the damage to railroads and bridges and other improvements and the cost of temporary flood-control measures.

#### *Sediment damages*

These damages include (a) the loss of reservoir storage capacity by accumulation of sediment expressed in per-acre-foot construction cost; (b) the cost of clearing excessive sediment from irrigation canals, laterals, and farm ditches; (c) the damages from excessive wear on

power equipment and the cost of cleaning settlement basins connected with power installations; (d) the cost of increased water treatment due to excessive amounts of silt.

## CURRENT STATUS OF WORK

### ACCOMPLISHMENTS.

Owners of private lands and lessees of State and private lands have been receiving assistance from the existing programs of the Department of Agriculture. At present, about two-thirds of the 7,800 farm operators are participants in Department of Agriculture programs.

The national forests are a bulwark in protection of critical head-water areas. Much progress has been made in adjusting grazing on these forests to the carrying capacity of the range. Protection from fire approaches desirable standards. Timber use has not assumed large proportions and it has not been possible to accomplish much in timber-stand improvement or in planting of denuded land. Development of national-forest recreational facilities has not kept pace with public use.

The State water-conservation board, the State engineer, the Colorado A. & M. College, and other State agencies and organizations in Colorado have made valuable contributions in solving problems relating particularly to flood control. Eleven soil-conservation districts comprising 1,192,000 acres have been created in the watershed. The Departments of Agriculture and Interior have been administering programs on the Federal lands under their respective jurisdictions. The Department of Interior has been actively engaged in the development of irrigation projects.

No concerted effort was devoted to the development or prosecution of a flood-control plan in this watershed until Congress passed flood-control legislation in 1936. Prior to that time, the Corps of Engineers had undertaken a limited study of flood-control problems. Under the authorizations of the 1936 and 1938 Flood Control Acts, the Department of Agriculture made preliminary examinations in the Bear Creek drainage, the Cherry Creek drainage, and the remainder of the South Platte River watershed. Detailed flood-control surveys have been completed in the Cherry Creek drainage and for the entire upper South Platte watershed. Findings from these surveys have been included in this report.

The Corps of Engineers recently completed the Cherry Creek Dam near Denver, Colo. Additional projects which Congress has authorized for construction by the corps include local protection works for the towns of Morrison, Erie, and Boulder, the Chatfield Reservoir on the South Platte River above Denver, and a continuous levee system from the Chatfield Dam to the mouth of the St. Vrain River.

There are also numerous county and municipal flood-protection works, most of which were constructed during the 1930's with the assistance of the Public Works Administration. Major projects include the Kenwood Dam on Cherry Creek and the Dry Creek Dam near Engelwood. Various channel-improvement structures have been installed along the course of Cherry Creek within the city limits of Denver and at various points on the main stem and tributaries of Plum, Bear, Dry, and Little Dry Creeks and the Cache la Poudre River.

## CURRENT RATE OF PROGRESS

The Department of Agriculture is currently spending about \$600,000 a year in this watershed for the installation of measures for development, use, and conservation of land, water, and forest resources. These funds are used for technical assistance and agricultural conservation payments on private lands and on State lands under lease, and for installations on national-forest lands. In addition, more than \$400,000 is expended annually on measures and practices which are recurrent or continuing in character.

The current rate of progress is about 1 percent of the total need annually. In other words, it would take 100 years to complete the developmental work at the present rate of expenditure. But some of the installations would probably never be undertaken under current programs.

## TOTAL NEEDED PROGRAM

The total needed program shown in table 2 includes agricultural measures and activities required for efficient development, utilization, and conservation of land, water, and forest resources of the watershed. It is designed to balance, complement, and support work of other Federal and State agencies directed toward flood control, water supply, hydroelectric power, and like purposes. Measures considered for grassland and cropland and those for forest and forest-range land are described separately in the following sections.

## MEASURES ON GRASSLAND AND CROPLAND

The program on grassland and cropland consists of measures designed to (1) hold the soil in place, (2) improve the soil fertility, (3) increase agricultural production consistent with the conservation of the land and water resources.

*Reseeding grasslands and pastures*

This measure is contemplated on badly depleted grasslands in the plains which cannot be rehabilitated by natural means, and on dry-farm croplands which should be restored to permanent cover. Total need, 173,000 acres; expected accomplishments with current programs in 20 years, 96,000 acres; recommended for accelerated program, 77,000 acres.



TABLE 2.—Total needed program, upper South Platte watershed  
[Long-term price projection]

Measures	Unit	Quantity	Installation cost				Total
			Federal cost		Non-Federal public	Private	
			On Federal land	On other land			
Measures for grasslands and croplands:							
Re seeding ranges and pastures	Acre	173,000	-----	\$298,700	\$298,700	\$1,700	\$374,300
Livestock-watering facilities	Number	8,895	-----	953,800	953,800	1,100	980,100
Lining of reservoirs	do	665	-----	74,400	74,400	-----	158,300
Fences	Mile	5,370	-----	999,900	999,900	9,600	1,181,400
Firrigators	do	1,800	-----	8,000	8,000	-----	9,800
Rodent control	Acre	112,800	-----	38,200	38,200	-----	84,400
Insect control	do	556,000	-----	133,400	133,400	-----	355,800
Control of poisonous and competitive plants	do	15,000	-----	23,200	23,200	-----	45,700
Contour furrows or pitting	do	150,000	-----	342,000	342,000	-----	22,500
Water spreading	do	73,000	-----	246,000	246,000	-----	168,000
Seeding grasses and legumes	do	241,000	-----	903,700	903,700	-----	119,000
Green manure and cover crops	do	26,000	-----	32,800	32,800	4,600	397,900
Crop residue management	do	285,000	-----	99,800	99,800	-----	131,000
Strip cropping	do	142,000	-----	35,500	35,500	-----	163,800
Terraces	Mile	6,000	-----	455,300	455,300	-----	85,000
Contour and cross-slope strip cropping	do	43,000	-----	20,600	20,600	3,000	369,600
Contour and cross-slope farming	Acre	70,000	-----	63,000	63,000	-----	17,200
Wind-erosion control	do	35,000	-----	22,800	22,800	-----	28,000
Fertilizer	do	60,000	-----	162,000	162,000	-----	224,700
Weed control	do	50,000	-----	86,500	86,500	-----	234,000
Outlets and waterways	do	7,700	-----	90,400	90,400	-----	126,000
Division dikes and ditches	Mile	800	-----	422,400	422,400	1,000	59,300
Erosion control structures	Number	10,400	-----	119,000	119,000	3,500	337,400
Roadside stabilization	Mile	735	-----	80,800	80,800	800	77,000
Stream-bank erosion control	do	100	-----	9,200	9,200	71,500	9,400
Grassland and pasture management	do	-----	-----	-----	-----	-----	7,700
Land leveling	Acre	322,000	-----	4,314,800	4,314,800	-----	6,311,200
Rehabilitation of irrigation ditches	Mile	4,500	-----	54,000	54,000	-----	40,500
Small irrigation structures	Number	53,500	-----	834,600	834,600	-----	1,572,900
Ditch lining	Square yards	5,300,000	-----	1,272,000	1,272,000	-----	3,392,000
Small irrigation ponds	Number	2,700	-----	155,200	155,200	-----	198,500
Drainage	do	170,000	-----	4,101,200	4,101,200	-----	4,016,200
Land surveys and maps	Square mile	3,100	-----	325,500	325,500	-----	325,500
Technical services for irrigation	Man-year	868	-----	5,210,000	5,210,000	-----	5,210,000

TABLE 2.—Total needed program, upper South Platte watershed—Continued  
[Long-term price projection]

Measures	Unit	Quantity	Installation cost				Private	Total
			Federal cost		Non-Federal public	Total Fed- eral cost		
			On Federal land	On other land				
Measures for grasslands and croplands—Continued								
Technical services for drainage	Man-year	266		\$1,600,000	\$1,600,000			\$1,600,000
Educational assistance	do	163		1,049,000	1,049,000	\$216,000		1,265,000
Subtotal				24,634,700	24,634,700	312,800	\$21,889,600	46,837,100
Measures for forest and forest range:								
Forest planting	Acre	33,000	\$1,440,000	15,000	1,455,000		30,000	1,485,000
Timber-stand improvement	do	67,000	1,876,000		1,876,000			1,876,000
Reseeding forest ranges	do	100,600	680,300	57,100	737,400		125,000	863,500
Fences	Mile	2,540	738,400	357,000	1,095,400	1,400		1,803,400
Stock-handling facilities	Number	270	105,300	52,500	157,800	10,100	60,900	218,700
Stock-watering facilities	do	1,640	431,700	75,900	507,600		92,400	600,000
Water spreading	Acre	2,980	50,000	14,200	64,200		74,200	138,400
Wildlife habitat improvement	do	30,000	390,000	84,000	474,000		111,000	585,000
Stream improvement	Mile	180	39,700	16,300	56,000		15,400	71,400
Recreation developments	Number	330	1,148,200		1,148,200			1,148,200
Winter sports areas	do	3	219,700		219,700			219,700
Stream pollution control structures	do	20	11,000	4,000	15,000		3,300	18,300
Special erosion control plantings	Acre	72,000	840,000	1,393,600	2,233,600	4,000	786,400	3,024,000
Shelter belts and wind breaks	do	3,000		180,000	180,000		102,000	282,000
Rodent control	do	380,000	201,500	21,600	223,100	1,500	20,900	245,500
Forest development roads	Mile	350	1,689,600	44,000	1,733,600	730,400		2,464,000
Fire control	do		77,700	4,800	82,500	4,800		87,300
Resource management	do							
Diversion ditches and dikes	Mile	445	381,600	23,400	405,000		11,100	424,100
Erosion-control structures	Number	17,320	309,700	10,700	320,400	8,000	3,600	329,100
Roadside stabilization	Mile	2,215	64,000	211,600	275,600	207,400	4,300	487,300
Stream-bank erosion control	do	165	27,400		27,400		700	28,100
Land surveys and maps	Square mile	5,840	336,000	277,200	613,200			613,200
Resource inventories and management plans	Acre	1,828,000	91,400		91,400		91,400	1,919,400
Land acquisition	do	580,000	9,280,000		9,280,000			9,280,000
Subtotal			20,429,200	2,842,900	23,272,100	972,700	2,074,900	26,319,700





*Livestock-watering facilities*

The development of additional ponds, wells, springs, and other livestock-watering facilities is necessary for better distribution of livestock and more equable utilization of range plants. These additional facilities, however, should be carefully coordinated with proper stocking and management in order to avoid the spread of overgrazing into new areas. Total needed units, 8,895; expected accomplishment with current programs in 20 years, 2,225; recommended for accelerated program, 6,670.

*Lining of reservoirs*

Occasionally a reservoir will leak after the dam has been built. In some cases there are risks of breaks in dams and potential flood damages. These reservoirs can be repaired with lining material such as bentonite, impervious clay, and asphalt-treated soil. The number requiring treatment, 665; the anticipated accomplishments with current programs in 20 years, 40; recommended for accelerated program, 625.

*Fences*

Additional fences must be constructed for proper management and use of range and pasture lands. Total need, 5,370 miles; expected accomplishments with current programs in 20 years, 860 miles; recommended for accelerated program, 4,510 miles.

*Fireguards*

Proper management of grassland will result in heavier vegetative cover and an accumulation of mulch on the ground. This condition will create a fire hazard which will not be limited to the grasslands but will also extend to cultivated crops. The construction of fireguards by removing vegetation from the surface for a width of 4 to 20 feet is a necessary precaution. These fireguards are usually placed along the roadside but sometimes are located along fence lines. Total need, 1,800 miles; expected accomplishment with current programs in 20 years, 200 miles; recommended for accelerated program, 1,600 miles.

*Control of rodents*

Prairie dogs, ground squirrels, gophers, rats, and other small animals destroy crops, weaken dams and ditches, and increase erosion and flood hazards. Although 564,000 acres need control measures, only 112,800 acres are now considered for treatment. Expected accomplishments with current programs in 20 years, 4,500 acres; recommended for accelerated program, 108,300 acres.

*Control of insects*

The control of grasshoppers, crickets, and various other endemic insects is necessary to reduce the risk of heavy crop damages and other losses in agricultural production. Area in need of treatment, 556,000 acres; expected accomplishments with current programs in 20 years, 110,000 acres; recommended for accelerated program, 446,000 acres.

*Control of competitive and poisonous plants*

The removal of poisonous, unpalatable, and otherwise undesirable and competitive plants and brush will improve the grassland cover and eliminate loss of livestock from these sources. Area in need of treat-

ment, 15,000 acres; expected accomplishments with current programs in 20 years, 2,000 acres; recommended for accelerated program, 13,000 acres.

#### *Contour furrows or pitting*

Pasture lands which have excessive surface runoff can retain more of the water where it falls through the use of contour furrows or the gouging of small shallow pits. These practices are limited to areas with adaptable soils and moderate slopes that are fairly free of rocks. Area needing treatment, 150,000 acres; expected accomplishments with current programs in 20 years, 6,000 acres; recommended for accelerated program, 144,000 acres.

#### *Water-spreading practices*

Small dams should be constructed in arroyos, along with dikes and ditches, to divert floodwaters to adjoining lands for useful purposes. Area where treatment is feasible and needed, 73,000 acres; expected accomplishment with current programs in 20 years, 60,000 acres; recommended for accelerated program, 13,000 acres.

#### *Seeding grass and legumes*

Seeding of grasses and legumes in crop rotations is a means of increasing forage yield, improving soil fertility and soil textures, and counteracting losses of fertility due to soil-depleting crops. Area to be seeded, 241,000 acres; expected accomplishments with current programs in 20 years, 160,000 acres; recommended for accelerated program, 81,000 acres.

#### *Green manure and cover crops*

These measures retard runoff and prevent erosion on cropland during the portion of the year when the ground is barren. They also add organic matter to the soil, improve its structure, increase its capacity to absorb water, and supply nutrients for plant growth. Area for treatment, 26,000 acres; expected accomplishments from current programs in 20 years, 6,000 acres; recommended for accelerated program, 20,000 acres.

#### *Crop-residue management*

This practice applies mostly to dry croplands producing small grains. It is accomplished by incorporating the stubble into the surface soil in such a manner that part of the stubble and straw is left on the surface. It affords protection from wind and water erosion and also increases organic content of the soil. Area for treatment, 285,000 acres; expected accomplishments with current programs in 20 years, 285,000 acres; recommended for accelerated program, none.

#### *Strip cropping*

This practice is primarily a wind-erosion-control measure and is used on level or gently sloping lands. It is applied by growing of alternate strips of protective and protected crops. The protective crops are close-grown grain, grasses, or legumes. They protect summer fallow and row crops from wind erosion. Area for treatment, 142,000 acres; expected accomplishments with current programs in 20 years, 8,000 acres; recommended for accelerated program, 134,000 acres.

### *Terraces*

Terraces will hold much of the precipitation on croplands in rolling country and dispose of the surplus water at nonerosive speeds. Properly designed terraces shorten slopes, encourage contour farming, and increase crop yields. At points where the surplus water is drained off, it is necessary to provide wide outlets on a moderate grade which must be planted to grass to prevent erosion. Total needs, 6,000 miles; expected accomplishments with current programs in 20 years, 1,000 miles; recommended for accelerated program, 5,000 miles.

### *Contour and cross-slope strip cropping*

This is used on sloping cropland where the soil is sandy and fine and subject to wind and water erosion. The measure consists of planting of strips of crops across slopes and on the contour. Area for treatment, 43,000 acres; expected accomplishment with current programs in 20 years, 5,000 acres; recommended for accelerated program, 38,000 acres.

### *Contour and cross-slope farming*

A combination of contour and cross-slope farming is feasible to stabilize cropland soils where the topography is broken and irregular. These practices are applied with terraces. Area for treatment, 70,000 acres; expected accomplishments with current programs in 20 years, 64,000 acres; recommended for accelerated program, 6,000 acres.

### *Wind-erosion control*

There are several means of controlling or modifying wind action on light, sandy soil in arid portions of the plains. These include contour listing, contour chiseling, basin listing, pit cultivation, and emergency listing at right angles to prevailing winds. The purpose is to break the smooth surface of the ground. Area for treatment, 35,000 acres; expected accomplishments with current programs in 20 years, 17,500 acres; recommended for accelerated program, 17,500 acres.

### *Fertilizers*

The application of fertilizers including phosphate, potash, sulfur, gypsum, and boron on grasses, sod waterways, legumes, and green manure and cover crops improves soil structure and increases fertility. In some cases fertilizers counteract such agents as alkali. Area for treatment, 60,000 acres; expected accomplishments with current programs in 20 years, 30,000 acres; recommended for accelerated program, 30,000 acres.

### *Weed control*

The control of weeds presents problems similar to those relating to competitive and poisonous plants, which are described above. Specifications for weed control should be prescribed by the State weed-control board. Area in need of treatment, 50,000 acres; expected accomplishments with current programs in 20 years, 6,600 acres; recommended for accelerated program, 43,400 acres.

### *Outlets and waterways*

This measure includes the filling of gullies, the reshaping of banks to more moderate slopes, and the planting of banks to sod-forming



grasses or legumes. It is used to check erosion and stabilize bottom lands along small drainages. In situations where fields are terraced it is sometimes necessary also to provide outlets and waterways including checks, drops, and diversions, as a means of releasing surplus water at nonerosive speeds. Total need, 7,700 acres; expected accomplishment with current programs in 20 years, 300 acres; recommended for accelerated program, 7,400 acres.

#### *Diversion dikes and ditches*

The construction of small dikes and diversion ditches for water spreading will reduce floodwater peaks and high sedimentation rates from small streams and increase native vegetation on the areas receiving the additional water. This work would be done in conformance with State laws governing water rights. Total needs, 800 miles; expected accomplishments with current programs in 20 years, 200 miles; recommended for accelerated program, 600 miles.

#### *Erosion-control structures*

Small dams, sometimes referred to as gully plugs, are helpful in arresting active gully erosion and stabilizing the soil in small drainages. They are ordinarily made with native materials close at hand, including rocks or a combination of rocks and brush. When this measure is installed, adjacent bottom lands and nearby slopes should be well covered with vegetation, otherwise the benefits will be spotty, partial, and temporary. Total number needed, 10,400; expected accomplishments with current programs in 20 years, 6,000; recommended for accelerated program, 4,400.

#### *Roadside stabilization*

The exposed surfaces along many of the roads are contributors of sediment and excessive surface runoff. This measure will reduce road maintenance costs and reduce damages to adjacent lands and improvements. It will be accomplished by the establishment of vegetation on the slopes, the stabilization of roadside and lead-out ditches, and the installation of interception and spreading ditches. Total need, 735 miles; expected accomplishments with current programs in 20 years, none; recommended for accelerated program, 735 miles.

#### *Stream-bank erosion control*

The removal of trees and shrubs along the streams with the intensive use of adjoining bottom lands has caused serious soil losses from stream-bank cutting. Establishment of special protective cover on the exposed stream banks will reduce erosion and aid in the stabilization of the stream course. Total need, 100 miles; expected accomplishments with current program in 20 years, none; recommended for accelerated program, 100 miles.

#### *Grassland and pasture management*

Many of the existing problems on grass and pasture lands are due to poor management practices. Research and experience have proved the beneficial effects of proper stocking, dispersion of grazing, rotation of grazing, and withholding livestock until the vegetation is ready for grazing. Provisions are made in the cost of individual measures for technical personnel to assist the private landowners in the planning of these installations for better management.

*Irrigated land leveling*

Croplands should be carefully graded to utilize irrigation water efficiently. This permits a more even application of water, prevents waste, and increases crop production. Area of land for leveling, 322,000 acres; expected accomplishments with current program in 20 years, 190,000 acres; recommended for accelerated program, 132,000 acres.

*Rehabilitation of irrigation ditches*

This work involves the laying out of ditches on nonerosive grades and requires competent engineering services. The measure is a "must" for irrigated cropland. Total need, 4,500 miles; expected accomplishment with current programs in 20 years, 1,500 miles; recommended for accelerated program, 3,000 miles.

*Small irrigation structures*

The manipulation of water in irrigation ditches requires numerous small control structures, including headgates, turn-outs, crossings, drops, flumes, weirs, siphons, and others. They are usually built with concrete, but sometimes lumber or ready-made structures are used. Total number needed, 53,500; expected accomplishments with current programs in 20 years, 6,250; recommended for accelerated program, 47,250.

*Ditch lining*

Practically all irrigation ditches have seepage losses in gravelly or sandy soils. Water is also lost to heavy vegetation along the banks. Lining of ditches with concrete or other material prevents these losses and reduces maintenance expense. Total need, 5,300,000 square yards of ditch lining; expected accomplishment with current programs in 20 years, 1,040,000 square yards; recommended for accelerated program, 4,260,000 square yards.

*Small storage ponds for irrigation*

On many of the farms, sources of water provide too small a flow for economical irrigation. It is often possible, however, to accumulate the flow overnight or for longer periods in small ponds so that a larger volume of water may be released from time to time. Total number needed, 2,700; expected accomplishments with current programs in 20 years, 640; recommended for accelerated program, 2,060.

*Drainage development*

In many locations, irrigated cropland or potential cropland needs drainage of waterlogged portions. This is customarily done by providing open ditches or drainage tile. Total need, 170,000 acres; expected accomplishments with current programs in 20 years, 86,000 acres; recommended for accelerated program, 84,000 acres.

*Land surveys and maps*

New land surveys and maps based upon up-to-date aerial photographs are necessary for detail-planning purposes. Total need, 3,100 square miles; expected accomplishments with current programs in 20 years, none; recommended for accelerated program, 3,100 square miles.

*Technical services for irrigation*

The opportunities to extend irrigation to additional lands are limited because of a lack of available water from either surface storage or

ground aquifers. Much can be done through land leveling and improvements of existing water distribution systems to increase efficiency in the use of water in existing areas. Additional technical service, however, is needed to assist farmers in applying irrigation practices for maximum crop production. Total needed technical services, 868 man-years; expected accomplishments with current programs in 20 years, 448 man-years; recommended for accelerated program, 420 man-years.

#### *Technical services for drainage*

The overuse of irrigation water in some areas has caused serious drainage problems. Excessive seepage from canals traversing pervious soils may also cause waterlogging of adjacent lands. Seepage and waterlogging have reduced the productivity of croplands in varying degrees even to the extent of total loss for crop production. Drainage problems in porous soils may be overcome by the installation of interception ditches and open drainage laterals. In areas with heavy-textured subsoils, closed or tile drains are necessary for proper drainage. Additional technical services are needed to assist farmers in planning and applying necessary remedial measures and in preventing new drainage problems. Total needed technical services, 266 man-years; expected accomplishment within 20-year period under current programs, 36 man-years; recommended accelerated program, 230 man-years.

#### *Educational assistance*

The success of the program is largely dependent upon active participation of farm families and active cooperation of farm groups, civic and commercial organizations, local, county, and State institutions, and governmental agencies. Participation and cooperation can be effected through more widespread knowledge of objectives of the needed program and the acceptance by farm people and governmental agencies of their responsibilities. Additional services and facilities should be provided to keep the local people fully informed on the needs and effects of the various aspects of the program. Total need, 163 man-years; expected accomplishment within 20-year period, 18 man-years; recommended for accelerated program, 145 man-years.

### MEASURES ON FOREST AND FOREST RANGE LAND

The program on forest and forest range lands will greatly strengthen the economy of the watershed through more intensive development, utilization, and conservation of the forest resources. The Federal Government has the major responsibility in this undertaking, since almost two-thirds of the lands are federally owned.

On the Federal lands the program will provide adequate protection from fire, insects, and disease, and will integrate measures for the various resources so as to maximize public benefits.

The program will also achieve high management standards on non-Federal public lands, with particular attention to State and local needs. Productiveness of private forest and forest range lands will be increased by better protection and good management practices.

#### *Forest planting*

Planting is required to restock badly depleted timber stands or denuded forest land. It is proposed in only those areas where natural



reforestation is inadequate. Total need, 33,000 acres; expected accomplishment with current programs in 20 years, 8,200 acres; recommended for accelerated program, 24,800 acres.

#### *Timber-stand improvement*

Timber-stand improvement consists mainly of thinning dense stands by the removal of inferior, diseased, defective, and suppressed trees. The removal of these trees reduces the competition for moisture, sunlight, and nutrients, and increases the growth in the residual stand. Pruning of the lower branches when the trees are small improves the quality of the timber when it reaches merchantable size. Total area for treatment, 67,000 acres; expected accomplishment with current programs in 20 years, 3,000 acres; recommended for accelerated program, 64,000 acres.

#### *Reseeding forest ranges*

Reseeding is proposed on only those badly depleted or denuded range lands which are suitable from the standpoint of topography, slope, depth, and type of soil, freedom from rocks, and adequacy of rainfall. Land with a moderately good stand of native perennial grasses which will recover naturally with protection, lighter grazing use, or improved management will not be considered. Total area for treatment, 100,600 acres; expected accomplishments with current programs in 20 years, 10,800 acres; recommended for accelerated program, 89,800 acres.

#### *Fences*

Fences are indispensable for the control of livestock and the proper management of range resources. Total needs, 2,540 miles; expected accomplishments with current programs in 20 years, 520 miles; recommended for accelerated program, 2,020 miles.

#### *Stock-handling facilities*

Corrals, loading chutes, cattle guards, and other facilities are necessary to handle and transport livestock. At present there is a deficiency of cattle guards. Total need, 270; expected accomplishments with current programs, 120; recommended for accelerated programs, 150.

#### *Stock-watering facilities*

Additional ponds, springs, wells, and other stock-watering facilities are needed to facilitate the distribution of livestock and equalize the utilization of the forage. Total need, 1,640; expected accomplishment with current programs in 20 years, 400; recommended for accelerated program, 1,240.

#### *Water spreading*

The proposed plan of water spreading is similar in character to that described under "Grassland and cropland." The only difference is that in the mountains the drainages are narrower and the bottom lands on which water can be spread are in small strips. Area for treatment, 2,980 acres; expected accomplishment with current programs in 20 years, 140 acres; recommended for accelerated program, 2,840 acres.

#### *Wildlife habitat improvement*

In a few areas, heavy grazing use by livestock or wild animals or both has depleted the wildlife habitat to such an extent that planting

is the only feasible means of restoration. Total need, 30,000 acres; expected accomplishments with current programs in 20 years, 3,400 acres; recommended for accelerated program, 26,600 acres.

#### *Stream improvement*

Many streams, and particularly the smaller ones, could be improved so that their fish-producing capacity would be substantially increased. This is done by the construction of small dams or deflector bars which form a system of pools and ripples for aeration. Total need, 180 miles; expected accomplishments with current programs in 20 years, none; recommended for accelerated program, 180 miles.

#### *Recreational developments*

The present facilities on the national forests are inadequate to provide for the steadily mounting recreation use. Additional needs include camp and picnic lay-outs, water and sanitation systems, shelters and other facilities mainly for the protection and safety of recreationists. Total number needed, 330; expected accomplishment with current programs in 20 years, 40; recommended for accelerated program, 290.

#### *Winter sports areas*

Skiing is an increasingly popular sport and adequate facilities should be provided for it on the national forests. This involves the selection of suitable ski courses, the clearing of timber, the removal of hazards, the installation of sanitation facilities, and building of short access roads. Usually ski-lift equipment is installed on national forest lands by individuals under a permit system and on a charge basis. Additional winter sports areas needed, three; expected accomplishments with current programs in 20 years, none; recommended for accelerated program, three.

#### *Stream pollution control structures*

A few dams, dikes, or other barriers are needed to keep mine tailings and other waste out of flowing streams. These would serve a very useful purpose in a few locations. Total need, 20; expected accomplishment with current program in 20 years, none; recommended for accelerated program, 20.

#### *Special erosion control plantings*

The repair of many actively eroding gullies requires special treatment. Planting of shrubs, sod-forming grasses, or other species, selected primarily for their soil-binding qualities, is a substantial help to the healing functions of nature. This work is done mostly in the small head drainages. Total need, 72,000 acres; expected accomplishments with current programs, 13,600 acres; recommended for accelerated program, 58,400 acres.

#### *Shelter belts and windbreaks*

While the plains of the South Platte watershed are not considered to be especially suitable for shelter belts and windbreaks, a few plantings should be made in selected areas to protect farm buildings from wind and snow. These plantings will also add to the attractiveness of the farmsteads. Total need, 3,000 acres; expected accomplishments with current programs in 20 years, 400 acres; recommended for accelerated program, 2,600 acres.

*Rodent control*

Plantations are frequently damaged by rodents which eat the tender bark and cripple or kill the young trees. In the mountain meadows extensive rodent burrowings may dry out the topsoil and shorten the growing season. Control is usually by poisoning, and is accomplished under the direction of the Fish and Wildlife Service or according to its specifications. Total need, 380,000 acres; expected accomplishment with current programs in 20 years, 126,000 acres; recommended for accelerated program, 254,000 acres.

*Development roads*

Additional roads are needed to protect, develop, and assure use of the forest resources. Access to remote timber areas will increase the annual cut of timber from national forest lands. Total need, 350 miles; expected accomplishment with current programs in 20 years, 140 miles; recommended for accelerated program, 210 miles.

*Fire control*

The restoration and improvement of the vegetative cover will increase the fire hazards. Additional facilities and personnel are necessary for the expansion and intensification of the existing fire-protection system to meet these changing conditions.

*Management of forest and range resources*

Application of the proposed measures on forest and forest range lands can do much toward increasing the productiveness of these lands and developing healthy forest conditions. The degree of their effectiveness rests largely upon proper integration and timing of their installation.

The ultimate success of the program is dependent upon better management of the resources. This is true on public as well as private lands. For example, the timber stands on national forests are well managed from a silvicultural standpoint, but improvements in management would provide greater protection to watershed values. On private lands, timber-cutting practices should be carefully planned by competent foresters to maintain good productive conditions and to prevent forest deterioration and watershed damage. Provisions are made in the costs of the individual measures for technical personnel to plan and supervise the program on public lands and to assist on private lands.

*Diversion ditches and dikes*

Diversion ditches and dikes reduce floodwater peaks and resulting sediment from small streams. They also serve to spread water to adjacent lands for the purpose of increasing the vegetation. Total need, 445 miles; expected accomplishments with current programs in 20 years, none; recommended for accelerated program, 445 miles.

*Erosion control structures*

Small dams made with native material are useful in the mountains as well as in the plains to arrest active gully erosion and to stabilize the soil in small drainages. Total need, 17,320; expected accomplishments with current programs in 20 years, none; recommended for accelerated program, 17,320.



*Roadside stabilization*

The purpose of this measure is to reduce road maintenance costs, to stabilize the soil on cut and fill slopes, and to reduce damages to other lands and improvements. These damages are caused by erosion from the exposed surfaces. The accomplishments will come from the establishment of vegetation on the slopes, the stabilization of roadside and lead-out ditches, and the installation of interception and spreading ditches. Total need, 2,215 miles; expected accomplishments with current programs in 20 years, none; recommended for accelerated program, 2,215 miles.

*Stream-bank erosion control*

Much of the stream-bank cutting in forest and range areas is due to heavy use along the stream courses. The planting of protective cover where needed and the installation of other conservation measures recommended will greatly reduce erosion from this source. Total need: 165 miles; expected accomplishments with current programs in 20 years, none; recommended for accelerated program, 165 miles.

*Land surveys and maps*

New maps based upon aerial photographs are needed for the compilation of resource inventories and development of detailed management plans. Total need, 5,840 square miles; expected accomplishments with current programs in 20 years, none; recommended for accelerated program, 5,840 square miles.

*Resource inventories and management plans*

A detailed inventory of the forest resources should be made and revised periodically. The aerial photographs to be used for new maps can also furnish much resource data such as the density of timber stands, size of trees, and other information. Detailed management plans, which should be developed and maintained currently, would include fire-control needs, transportation requirements, and other information essential to the development and use of the forest and range resources. Total area, 1,828,000 acres; expected accomplishments with current programs in 20 years, none; recommended for accelerated program, 1,828,000 acres.

*Land acquisition*

Sizable areas of privately owned lands within and immediately adjacent to the national forest possess important public values. These lands should be managed in such a manner that the public values are permanently protected. To prevent excessive runoff and erosion, some of them which have rough topography and erodible soil types should be used sparingly and with great care. Some are situated so that they adversely affect the administration and management of adjoining public lands. Some have been heavily cut, overgrazed, or otherwise abused, while others may be excessively used in the future. The restoration of denuded timberlands or overgrazed ranges to productive condition often involves such heavy investment without return for such a long period of years that private owners cannot be expected to undertake it. In many cases, the lands with high watershed values can be given the required special attention only in public ownership. Individual properties would be acquired only as the owners were

willing to sell at a reasonable price. Total need, 580,000 acres; expected accomplishments with current programs in 20 years, 8,000 acres; recommended for accelerated program, 572,000 acres.

#### MEASURES FOR STABILIZING SMALL WATERCOURSES

##### *Detention structures*

Detention structures should be installed principally in the foothill areas to retard excessive runoff from melting snow and rain. They are especially useful in controlling flash floods from summer thunderstorms. They are designed particularly to protect improvements at lower elevations from flood damages but also serve to a minor extent for sediment storage. The design will be of earth fill, masonry, or concrete construction, and the structure will be equipped with ungated concrete outlets and adequate spillways. Total number of structures, 53; expected accomplishments with current programs in 20 years, none; recommended for accelerated program, 53.

##### *Sediment retention structures*

Sediment retention dams are necessary below the more critical eroding areas primarily to prevent sediment damages at lower elevations but also to a minor extent retard excess surface runoff. They will catch much of the sediment near the source while the land treatment measures become effective. The design will be earth fill, masonry, or concrete construction, and the structure will be equipped with adequate spillways. Total number of structures needed, 35; expected accomplishments with current programs in 20 years, none; recommended for accelerated program, 35.

##### *Channel improvements*

Practically all of the tributary channels in the plains and many in the mountains are being damaged by bank cutting, degradation, and aggradation. This results in damages downstream by sediment and overflow. The detention dams upstream will reduce peak flows but channel improvements are also needed.

The proposed works consist of: (1) Improvements to the channel itself, (2) improvements or modifications of present structures in the channel which are now impairing the hydraulic efficiency of the channel. They include channel enlargement work, stabilizing weirs, riprapping, channel clearing, stream-bank planting, improvements in irrigation ditch crossings, and other measures. Total need, 120; expected accomplishments with current programs in 20 years, none; recommended for accelerated program, 120.

##### *Stabilizing and sediment control structures*

Many small eroding areas are in need of structures to reduce present high sedimentation rates. Treatment includes primarily the construction of small retention dams averaging about 2 acre-feet capacity. Total need, 1,750; expected accomplishment with current programs in 20 years, none; recommended for accelerated program, 1,750.

*Road erosion control*

The present road and highway damages reflected in high maintenance costs are due to inadequate drainage facilities, raw cut and fill slopes, and other factors. These conditions will be improved by the integration of the necessary drainage structures with the roadside stabilization measures, and by the raising of existing bridges and approach roads for greater headroom. Total mileage needing treatment, 3,025; expected accomplishments with current programs in 20 years, none; recommended for accelerated program, 3,025 miles.

## RESEARCH AND SOIL SURVEYS

An accelerated program of research and investigations, including soil surveys, is needed as an integral part of the comprehensive program for the South Platte River watershed, in order to make possible the most efficient application of this program to the land. As planned in this report, the proposed research program will be designed to supply data for specific work plans in small areas and on farms; it will show the benefits accruing to farmers and others who take part in the program; and it will provide an equitable basis for sharing costs between individual farmers, local groups, State and Federal Governments, as well as between landlords and tenants. On forest and range lands, the research program will make improved management possible through more efficient utilization of the timber and range resources. It will show to what degree these resources can be used to provide maximum supplies of wood, forage, and water without damaging the productive capacity of the watershed or causing floods and erosion. The surveys and other investigations will help land users and managers plan the work to be done on the land more exactly and efficiently than is possible at present. They will help meet the need for solving special problems in particular areas. And, finally, all of the research program will help measure the results of the comprehensive program so as to help improve future application in the South Platte watershed and improved programs planned for other areas.

Only Federal moneys are included in the estimates of research costs summarized in table 3. Research and soil surveys will be carried on cooperatively by the Department of Agriculture and State agencies and the States will be expected to make contributions within their capacity to do so. The estimates of Federal contribution that are shown may therefore be reduced.

The cost estimates are shown only for the first 10 years of the program. At the end of that time it will be decided what research needs to be continued, the costs of continuation, and whether any new problems should be added to the program.



TABLE 3.—*Estimated Federal cost of research and soil surveys, upper South Platte watershed (10-year program)*

<i>Type of research</i>	<i>Total cost of recommended program</i>
Conservation and management of farm and ranch land:	
Soil and water management.....	<sup>1</sup> \$270, 000
Economic research.....	150, 000
Subtotal.....	420, 000
Forest and range research:	
Watershed management.....	547, 000
Forest management.....	446, 000
Range management.....	430, 000
Fire control.....	226, 000
Forest products.....	231, 000
Forest economics.....	250, 000
Subtotal.....	<sup>2</sup> 2, 130, 000
Irrigation development:	
Water, soil, and plant relationships.....	<sup>3</sup> 522, 000
Economic problems.....	150, 000
Subtotal.....	672, 000
Soil surveys and land classification: Subtotal.....	478, 000
Total.....	<sup>4</sup> 3, 700, 000

<sup>1</sup> Installation cost \$30,000.<sup>2</sup> Installation cost \$325,000.<sup>3</sup> Installation cost \$35,000 and it is expected that the Bureau of Reclamation will provide additional installation cost including 1 or more development farms.<sup>4</sup> It is expected that the Colorado Agricultural Experiment Station will provide additional funds for cooperative research. The State of Colorado is currently providing \$14,000 annually for soil surveys.*Conservation and management of farm and ranch land*

*Management and conservation of soil and water.*—The upper South Platte watershed includes some 500,000 acres of dry-farm and ranch lands. Maximum production is not now being realized. Many factors probably are responsible. Among these are decreased levels of nitrogen and phosphorus which limit crop production in seasons of good precipitation; low infiltration rates of the soils which cause excessive losses of rainfall by runoff; and soil erosion which removes the more fertile topsoil on the exposed slopes. The productivity of these lands could also be increased through use of crops and crop varieties better adapted to the area, better tillage, and improved fallowing practices. Rotation practices also should be carefully scrutinized. In an area such as the upper South Platte watershed where the agricultural economy is dependent upon both dry-land and irrigation farming, it is particularly important that the dry-land and irrigation problems be studied concurrently.

*Economic problems of conservation.*—The basin-land conservation program requires close and cooperative relationships among farm operators and landowners working toward common objectives. Information is needed to answer questions such as: (1) Will it pay the individual operator to adopt the conservation program on his farm; (2) what are the public benefits and costs of conservation farming; (3) what are the types of tenure arrangements, local organization, and inducements and incentives that are needed to achieve a well-balanced conservation program? Another major problem centers around the use of publicly owned land in the upper part of the area and its interrelation with

privately owned land. Privately owned lands are often dependent upon the public lands for seasonal grazing. Use of the public lands affects water supplies for the private lands. Intermingled with the public lands are many small tracts of privately owned land used for various purposes. The conservation and management problems are complicated because public lands are generally used for multiple purposes while adjacent and interdependent privately owned lands are devoted to single uses. More information is needed to appraise the economic relationship of publicly owned and privately owned lands in this area.

#### *Forest and range research*

The primary objectives of an expanded forest and range research program are to strengthen the basis for more effective resource management and to seek solutions to local problems relating to the efficient application of the remedial measures. The results of these investigations and studies can be used in areas with similar conditions outside the watershed and will be valuable information in the development of subsequent supplemental reports.

*Watershed management.*—An expanded research program will provide data on the effects of different methods and different intensities of forest, range, and cropland use in reducing soil erosion, sedimentation, and flood damage. It will include short-term studies in determining some of the most rapid and economical means of reducing accelerated sheet, gully, and stream-bank erosion of the critical foothills portion of the watershed. Owing to the steepness of slope, the erosiveness of the soil, and the occurrence of torrential summer showers, the foothill region poses serious problems of torrent control. Special engineering research is also needed for increasing the temporary channel storage capacity in these steep rocky areas as well as in measuring the effects of a watershed treatment program in regulating flood flows.

Research and investigations will involve collection and interpretation of records on precipitation, amounts and rates of stream flow, sediment load of streams, and silting of storage and flood-detention reservoirs. The investigations will be carried on in natural watersheds in a manner to reflect the relationship of soils, land use, size of drainage area, and other related watershed features.

More study should be given to the economic problems of applying practices and measures for controlling runoff, siltation, and sediment transportation. Concentration of property in flood plains has built up high economic values. Consequently, severe floods result in heavy economic losses. A study should be made of the relationship between use of flood plains and flood damage, and the economic benefits of various approaches to reduction of flood damage. This should include study of the direction of economic development in certain parts of the flood plain by such devices as rural zoning.

*Forest management.*—An expanded program of research will give findings on the best methods of harvest cuttings, cultural treatments in young forests, methods of protecting and managing timber growth for sustained yield and, in connection with forest-products research, the development of more efficient procedures for logging in difficult terrain, and improvement in small portable mill practices.

*Range management.*—An expanded program of research will emphasize the use of the best adapted practices in range utilization for the purpose of rehabilitating mountain watersheds. This will cover problems and methods of reseeding, systems of grazing reseeded areas, and research in species and mixtures for seeding. In addition, the program will include the establishment of experimental areas in the foothills portion of the watershed to study range use of the mountain brush and cheatgrass cover types. It will be carried on in conjunction with watershed management research.

*Fire control.*—An expanded research program will be directed to finding ways of reducing fire losses on both forested and nonforested areas. These studies will involve the development of better methods of fire control, improvement in fire-fighting equipment, and more accurate prediction of fire weather and fire hazards.

*Forest products.*—In conjunction with forest-management research, an expanded program will be directed toward the development of improved logging techniques and transportation facilities. New equipment and revised methods of road construction will be devised to meet specialized conditions encountered at high altitudes. New and better ways of using wood products from the less desirable species, and improved techniques in cutting timber to reduce waste, will be developed. This will involve pilot-plant studies to improve small portable mill practices, and techniques for kiln drying and timber preservation.

*Forest economics.*—An expanded research program will be directed toward a comprehensive inventory of timber, range, forage, and water resources, to studies of use-owner-tenure relations, to most economical ways of developing forestry resources, and to studies of markets for forest products and marketing problems.

#### *Irrigation development*

*Water, soil, and plant relationships in crop production on irrigated lands.*—The Colorado-Big Thompson project will bring thousands of acre-feet of water from the west slope of the Rockies into this watershed, for use on its existing irrigated lands. Introduction of this new water will create many problems. These include problems of irrigation methods, drainage, alkali, salinity, fertility, and cultural practices. Some land is already declining in productivity as a result of excess alkali or salts and inadequate drainage. Addition of new water will accelerate waterlogging and salt accumulation.

The water diverted to the east slope to supplement existing supplies will be delivered to farmers for the most part through existing canals and laterals. Administration and delivery of this water will raise problems for each irrigation enterprise subscribing for water.

Many millions of dollars are being spent to develop the additional water. It is therefore imperative to use these waters effectively and avoid economic loss to farmers by determining and using water and soil management and crop production practices suited to the different soils. Research is necessary to make this possible.

This research would be undertaken cooperatively by the Department of Agriculture and the Colorado Agricultural Experiment Station at development farms, on farmers' fields, and in the laboratory and greenhouse. It is expected that the Bureau of Reclamation will provide land for experiments on one or more development farms.



*Economic problems of irrigation.*—Investigations are needed of farm development costs and changes in the economy due to additional water for irrigation. Studies will be directed at alternate repayment arrangements, costs, and returns from different methods of applying irrigation water, and the extended benefits of irrigation in population increases, industrial growth, and increased business activity. Marketing problems arising from shifts or increases due to additional irrigation will be studied. Other studies will be aimed at means of using irrigation development to achieve maximum stability of agricultural production and of local government and institutions, and appropriate leasing and tenure arrangements for irrigated farms.

*Soil survey and land classification*

To complement the new irrigation which will result from the additional water diverted from the west side of the mountains, a very detailed soil survey will be needed on about 120,000 acres. Less detailed soil surveys will be needed on an additional 4,500,000 acres. Of these, 500,000 acres of farm lands need moderately detailed surveys; 4,000,000 acres of forest range and grassland need much less detailed survey.

The farm-land surveys should be completed during the first 6-year period in order to be of greatest service in irrigation development.

A comprehensive soil investigation can furnish basic data necessary to strengthen and improve present management practices on the forest and range lands. An expanded program will be directed toward gathering information concerned with soil associations and complex soil conditions with recognition of parent material, texture, slope, erosion characteristics, and types of vegetation existing as ground cover. The program will include laboratory analyses of the physical and chemical properties of the various soils, together with their water-storage capacity and permeability as a basis for evaluating potential site productivity. Where possible, surveys will be carried on concurrently with forest and range inventories.

#### PROGRAM APPRAISAL

The installation of the total needed program will result in substantial increases in production from cultivated, grass, and forest lands. Damages from floods and sediment will be greatly reduced. Many other benefits will accrue from the processing of products and the increased volume of trade generated by the increased production of the land. No attempt has been made to make a monetary calculation of the effect of installing the entire program. Benefits will begin to appear as soon as installations are made. But many years will elapse before the full benefits from more intensive management and conservative use of forest and range resources and the gradual increase in land productivity are felt.

#### INCREASED PRODUCTIVITY OF WATERSHED LANDS

On the croplands in the plains portion of the watershed, increased yields will result from approved cropping and tillage practices and other measures to reduce erosion and increase available soil moisture; from measures to improve the conveyance and application of water on

irrigated lands; from drainage and conversion of presently low producing lands to cultivated use; from special aids to increase soil fertility; and from research on production problems.

Increased benefits from grassland come from the restoration of deteriorated lands, from an increase in acreage due to conversion of the rougher cultivated areas to a more permanent grass cover, from additional watering facilities, and from improved management and research to obtain proper stocking, rotation, dispersion, and timeliness of grazing.

From the forests and forest-range lands in the foothill and mountain portions of the watershed comes the water that is so important to the economy of the plains below. Measures proposed for these lands are designed to preserve and enhance the vital water storage function and, in harmony with this use, provide maximum benefits in the form of increased yields of wood products, increased forage production, increased recreational use, and the like. Reforestation, fencing, construction of access roads, reseeding, improved stock handling and watering facilities, adjustments in livestock use, fire protection, recreational developments, and expanded research are the principal measures that will preserve and increase the benefits from these lands.

The value and the necessity of the recommended program should be considered from another important standpoint. Unless proper conservation of the soil and the land resource is achieved within a relatively short span of years, the accumulated damages and progressive deterioration will require more expensive remedial treatment with less possibility of recovery.

#### EFFECT OF PROGRAM ON FLOOD DAMAGE

Reduction of flood and sediment damage in the watershed depends in large part upon the proper integration and the timeliness of installation of practices and measures recommended in this report.

The total needed program, when applied, will increase the intake of water into the soil, retard the movement of excess runoff, and convey the water along the least damaging routes to major rivers.

Many of the measures recommended for the conservation and improvement of crop, pasture, and forest land will contribute toward reducing erosion, inundation, and sediment damages, as well as toward increasing production.

Further reduction in these damages will result from complementary measures and works not ordinarily constructed by private landowners, such as the program of stabilizing measures for small watercourses. In addition, these measures make possible the proper installation and continued effectiveness of many of the measures recommended for the conservation and improvement of other lands.

Among additional benefits that will result from reduction of flood crests by means of this program are less interruption of transportation and other public services, and less risk to human life.

As a result of the installation and maintenance of measures in the recommended accelerated program for waterflow retardation and soil-erosion prevention, flood-water damages will be reduced about \$230,200 and sediment damages \$265,300 annually.

## RECOMMENDED ACCELERATED PROGRAM

To carry out the total needed program in the upper South Platte watershed within a 20-year period will require acceleration of work above the current rates and the installation of some measures not now included in the current programs of the Department of Agriculture.

In table 4 are set forth the items of work and estimated costs that will be required in addition to current programs to complete the total needed program in 20 years. The cost of installing the recommended accelerated program is \$64,048,300, shared as follows:

Federal.....	\$48, 853, 800
Non-Federal public.....	1, 891, 200
Private.....	13, 303, 300

TABLE 4.—Recommended accelerated program, upper South Platte watershed

[Long-term price projection]

Measures	Unit	Quantity	Installation cost			
			Federal	Non-Federal public	Private	Total
Measures for grasslands and croplands:						
Reseeding ranges and pastures	Acre	77, 000	\$137, 000	\$1, 700	\$161, 500	\$300, 200
Livestock-watering facilities	Number	6, 670	679, 600	1, 100	461, 400	1, 142, 100
Lining of reservoirs	do	625	70, 400		78, 300	148, 700
Fences	Mile	4, 510	868, 400	9, 600	962, 000	1, 840, 000
Fireguards	do	1, 600	4, 900		3, 800	8, 700
Rodent control	Acre	108, 300	37, 200		44, 000	81, 200
Insect control	do	446, 000	103, 900		283, 500	392, 400
Control of poisonous and competitive plants	do	13, 000	20, 200		19, 500	39, 700
Contour furrows and pitting	do	144, 000	328, 800		160, 800	489, 600
Water spreading	do	13, 000	48, 000		17, 000	65, 000
Seeding grasses and legumes	do	81, 000	418, 000	4, 600	383, 400	806, 000
Green manure and cover crops	do	20, 000	25, 200		100, 800	126, 000
Strip cropping	do	134, 000	33, 500		26, 800	60, 300
Terraces	Mile	5, 000	379, 500	3, 000	307, 500	690, 000
Contour and cross-slope strip-cropping	Acre	38, 000	18, 200		15, 200	33, 400
Contour and cross-slope farming	do	6, 000	5, 400		2, 400	7, 800
Wind-erosion control	do	17, 500	11, 400		11, 400	22, 800
Fertilizer	do	30, 000	81, 000		117, 000	198, 000
Weed control	do	43, 400	75, 100		109, 400	184, 500
Outlets and waterways	do	7, 400	87, 500	1, 000	57, 300	145, 800
Diversion dikes and ditches	Mile	600	314, 800	3, 500	254, 100	572, 400
Erosion-control structures	Number	4, 400	49, 400	800	33, 400	83, 600
Roadside stabilization	Mile	735	80, 800	71, 500	9, 400	161, 700
Stream-bank erosion control	do	100	9, 200		7, 800	17, 000
Grassland and pasture management.						
Land leveling	Acre	132, 000	1, 768, 800		2, 587, 200	4, 356, 000
Rehabilitation of irrigation ditches	Mile	3, 000	36, 600		26, 400	63, 000
Small irrigation structures	Number	47, 250	737, 100		1, 389, 200	2, 126, 300
Ditch lining	Square yard	4, 260, 000	1, 022, 400		2, 726, 400	3, 748, 800
Small irrigation ponds	Number	2, 060	118, 500		151, 400	269, 900
Drainage	Acre	84, 000	1, 820, 300		803, 300	2, 623, 600
Land surveys and maps	Square mile	3, 100	325, 500			325, 500
Technical services for irrigation	Man-year	420	2, 510, 800			2, 510, 800
Technical services for drainage	do	230	1, 385, 000			1, 385, 000
Educational assistance	do	145	960, 000	200, 000		1, 160, 000
Subtotal			14, 577, 400	296, 800	11, 311, 600	26, 185, 800



TABLE 4.—*Recommended accelerated program, upper South Platte watershed—Con.*

Measures	Unit	Quantity	Installation costs			
			Federal	Non-Federal public	Private	Total
<b>Measures for forest and forest range:</b>						
Forest planting.....	Acre.....	24, 800	\$1, 083, 900	-----	\$32, 000	\$1, 115, 900
Timber-stand improvement.....	do.....	64, 000	1, 667, 000	-----	125, 000	1, 792, 000
Reseeding forest ranges.....	do.....	89, 800	699, 700	\$1, 400	71, 100	772, 200
Fences.....	Mile.....	2, 020	923, 700	10, 100	500, 300	1, 434, 100
Stock-handling facilities.....	Number.....	150	86, 700	-----	34, 800	121, 500
Stock-watering facilities.....	do.....	1, 240	418, 800	-----	37, 800	456, 600
Water spreading.....	Acre.....	2, 840	62, 400	-----	8, 600	71, 000
Wildlife habitat improvement.....	do.....	26, 600	223, 400	-----	295, 300	518, 700
Stream improvement.....	Mile.....	180	56, 000	1, 900	13, 500	71, 400
Recreational developments.....	Number.....	290	1, 022, 200	-----	-----	1, 022, 200
Winter sports areas.....	do.....	3	219, 700	-----	-----	219, 700
Stream-pollution-control structures.....	do.....	20	11, 000	1, 800	5, 500	18, 300
Special erosion-control plantings.....	Acre.....	58, 400	1, 726, 200	4, 000	722, 600	2, 452, 800
Shelter belts and windbreaks.....	do.....	2, 600	156, 000	-----	88, 400	244, 400
Rodent control.....	do.....	254, 000	151, 200	4, 300	9, 500	1, 165, 000
Forest development roads.....	Mile.....	210	1, 345, 600	132, 800	-----	1, 478, 400
Fire control.....	do.....	-----	82, 500	4, 800	-----	87, 300
Resource management.....	do.....	-----	-----	-----	-----	-----
Diversion ditches and dikes.....	do.....	445	405, 200	8, 000	10, 900	424, 100
Erosion-control structures.....	Number.....	17, 320	320, 400	5, 100	3, 600	329, 100
Roadside stabilization.....	Mile.....	2, 213	275, 600	207, 400	4, 300	487, 300
Stream-bank-erosion control.....	do.....	165	27, 400	-----	700	28, 100
Land surveys and maps.....	Square mile.....	5, 840	613, 200	-----	-----	613, 200
Resource inventories and management plans.....	Acre.....	1, 828, 000	91, 400	-----	-----	91, 400
Land acquisition.....	do.....	572, 000	9, 152, 000	-----	-----	9, 152, 000
Subtotal.....	-----	-----	20, 821, 200	381, 600	1, 963, 900	23, 166, 700
<b>Measures for stabilization of small watercourses:</b>						
Detention structures.....	Number.....	53	5, 458, 300	231, 700	-----	5, 690, 000
Sediment retention.....	do.....	35	609, 000	16, 400	-----	625, 400
Channel improvements.....	Mile.....	120	791, 800	249, 600	27, 800	1, 069, 200
Stabilizing and sediment-control structures.....	Number.....	1, 750	1, 062, 600	132, 700	-----	1, 195, 300
Road-erosion control.....	Mile.....	3, 025	730, 500	582, 400	-----	1, 312, 900
Subtotal.....	-----	-----	8, 652, 200	1, 212, 800	27, 800	9, 892, 800
<b>Research and soil surveys:</b>						
Research.....	-----	-----	3, 222, 000	-----	-----	3, 222, 000
Soil surveys and land classification.....	-----	-----	478, 000	-----	-----	478, 000
Subtotal.....	-----	-----	3, 700, 000	-----	-----	3, 700, 000
Total.....	-----	-----	47, 750, 800	1, 891, 200	13, 303, 300	62, 945, 300

FOOTNOTE.—Federal expenditures for "Technical assistance" is estimated at \$2,573,000; and for "Administration of direct aids," \$1,221,000. The total included in costs of recommended measures is \$3,794,000.

The estimated costs include expenditures for labor, material, technical assistance, and administration of direct aids required to install the recommended measures. These costs estimates were obtained insofar as possible from agencies doing similar types of work in the watershed. For recurring measures, the installation cost covers only the cost of establishing the new practices in land use and management. All estimates reflect long-range projected prices.

The measures recommended are interdependent and they should be implemented as a single program. The measures will be applied on various classes of land in appropriate proportions and sequence.

## RECURRENT ANNUAL COSTS

The installation of the recommended accelerated program will require additional funds to finance recurrent annual expenditures for the protection, maintenance, and operation of the measures in order to insure their continued effectiveness. These annual costs will be relatively low during the initial stages of the program but will increase as the installation progresses, reaching a maximum at the end of the 20-year period. The Federal funds for recurrent annual costs which are summarized below are needed together with those for installation purposes to fulfill the Federal responsibilities in undertaking the accelerated program.

At the end of the 20-year installation period the annual protection, maintenance, and operation costs of land-treatment measures and stabilizing measures contributing to water-flow retardation and soil-erosion prevention are estimated at \$224,500, of which \$125,200 is the Federal share. The annual protection, maintenance, and operation costs of development measures on national-forest lands, not installed for flood-control purposes, will be approximately \$133,900 at the end of the 20-year period.

During the installation period, recurrent Federal costs for protection, maintenance, and operation of measures installed under the recommended program on national forests and for increased cooperative fire protection on private lands will total \$2,769,000. This amount is recommended for authorization as part of the recommended accelerated program. No other costs for maintenance and operation of measures installed on private lands are recommended for authorization.

## ECONOMIC JUSTIFICATION

Benefit-cost ratios have been calculated for those measures in the recommended accelerated program that contribute significantly to water-flow retardation and prevention of soil erosion.

The benefit-cost ratios for land-treatment measures contributing to water-flow retardation and soil-erosion prevention are calculated separately from measures for stabilizing small watercourses. The types of treatment are interdependent, however, and can be applied successfully on the lands only if all the integrated parts are authorized and implemented to be carried out as one project in proper sequence and proper proportions on each farm and subwatershed. Annual work plans will be prepared for this purpose.

In calculating the benefit-cost ratios, a 2½-percent interest rate was applied to Federal and other public expenditures and a 4-percent rate to private expenditures.

*Costs and benefits from land-treatment measures that contribute to water-flow retardation and soil-erosion prevention*

With the installation of the land-treatment measures that contribute to water-flow retardation and soil-erosion prevention, there will be a reduction in anticipated flood and sediment damages of about 13 percent, resulting in benefits of \$151,000. Annual benefits attributable to increased productivity of croplands and grasslands are estimated at \$768,000. Increased production from forest lands due to increased growth rates of about 35 percent accompanied by decreased fire losses

will result in annual benefits of about \$181,500. All together, the average annual benefit resulting from the installation and maintenance of these measures totals \$1,100,500.

The average annual equivalent value of the cost of these measures, including maintenance, is \$406,500.

The ratio of benefits to costs for land-treatment measures that contribute to water-flow retardation and soil-erosion prevention is 2.7 to 1.0.

#### *Costs and benefits from measures for stabilizing small watercourses*

Floodwater detention dams installed above critical areas sustaining severe damages will provide temporary storage for excess runoff. They will reduce both agricultural and nonagricultural damages and will be effective immediately upon installation. The installation of sediment retention structures below the more critical eroding areas in combination with other treatments will reduce sediment damages to improvements below and will also retard excess runoff and reduce floodwater damages. Damages resulting from bank cutting and channel aggradation and degradation will be reduced by channel improvement work including riprapping, establishment of stabilizing weirs, channel clearing, and other treatment. The installation of stabilizing and sediment control structures in combination with channel improvement work and other measures will greatly reduce gully erosion and sediment damages and will provide relief until the land-treatment measures become fully effective. Road erosion control treatment including the stabilizing of cut and fill banks, installation of interception and lead-out ditches and improvements by enlargement or replacements of existing culverts, bridges, and other drainage facilities, will greatly reduce presently excessive damages to roads and highways.

The design and specifications for these measures are such that they may be maintained at a very low annual cost provided they are installed in conjunction with the land-treatment measures. However, partial replacement may become necessary from time to time because of conditions over which there is no control.

The recommended measures installed on land not under the jurisdiction of the Federal Government are to be operated and maintained by State or local agencies under arrangements acceptable to the Secretary of Agriculture, and installation in any area will not be commenced until such arrangements have been made. The boundaries of any such area shall be determined by the Secretary.

It is estimated that the installation and maintenance of measures for stabilizing small watercourses will result in annual benefits due to reductions in floodwater and sediment damages of \$344,500 of which \$171,900 is attributable to reduced sediment damages and \$172,600 to reduced floodwater damages.

The annual cost of installing this stabilizing program including maintenance is \$321 500.

The ratio of benefits to costs for measures for stabilizing small watercourses is 1.1 to 1.



SECTION IV  
OSAGE RIVER WATERSHED (KANSAS AND MISSOURI)

C O N T E N T S

	Page
Description of watershed.....	157
Economic development.....	160
Desirable pattern of land use.....	171
Current status of work.....	172
Total needed program.....	174
Program appraisal.....	187
Recommended accelerated program.....	191

LIST OF TABLES

Table	
1. Average annual flood damage.....	169
2. Use of agricultural land, present and planned.....	171
3. Cost of research and soil surveys.....	191
4. Total needed program.....	192
5. Recommended accelerated program.....	193



## SECTION IV

### OSAGE RIVER WATERSHED (KANSAS AND MISSOURI)

#### DESCRIPTION OF THE WATERSHED

##### LOCATION AND SIZE

The Osage River watershed is located in Kansas and Missouri (see map). The total drainage area is 15,300 square miles, of which 4,300 square miles are located in east-central Kansas and 11,000 square miles in west-central Missouri. It comprises 2.94 percent of the Missouri River watershed within the United States.

##### PHYSICAL LAND CHARACTERISTICS

The river rises in east-central Kansas near Eskridge, and flows eastward to its junction with the Missouri River near Jefferson City, Mo. From its source in Kansas to the junction with the Little Osage River in Missouri it is the Marias des Cygnes River and from this point to its mouth it is the Osage River. For convenience in this report the entire river will be referred to as the Osage River.

The watershed occupies parts of two major physical land areas, the Ozark highlands, comprising 46.5 percent of the watershed, and the central prairies, comprising 53.5 percent of the watershed. The eastern part of the watershed, comprising nearly all of the area below Osceola, Mo., lies in the Ozark highlands. The rest is in the central prairies.

The Ozark highlands have smooth ridges, steep valley slopes, and deeply entrenched, meandering streams. Most of the area consists of the rough stony slopes. The divides and the flood plains are usually narrow. The relief or difference in elevation between the ridge tops and the flood plain is about 450 feet.

The central prairies are characterized by gently rolling uplands with relatively broad, shallow valleys. The relief is generally less than 200 feet. The gently rolling uplands are interrupted at intervals by irregular east-facing escarpments. These are capped by a layer of hard rock, usually limestone or sandstone.

##### CLIMATIC CONDITIONS

The normal climate of most of the Osage River watershed is humid. However, the extreme western part lies in the moist subhumid climate belt. Thus the climatic conditions are normally favorable to agricultural production throughout the watershed.

The mean annual temperature is about 56°. The average for July is 78°, and the highest temperature of record is 118°. The average for January is 32°, and the lowest temperature of record is minus 40°.



Temperatures suitable for growing crops prevail for approximately 6 months during spring, summer, and fall.

The average annual precipitation varies from about 42 inches in the eastern part of the watershed to about 38 inches in the western part. About 65 percent of this falls during the 6-month growing season. The heaviest rainfall occurs in May, June, and July, when it is most needed for crops and pasture. However, much of the rainfall during these months comes from torrential thunderstorms, and loss by runoff is high. Such rains also cause much of the soil erosion loss. The annual rainfall varies from about 24 inches to about 54 inches. The average snowfall is about 20 inches. Severe droughts may occur during all seasons, particularly in the western part of the watershed. These cause serious crop damage, especially in July and August.

The watershed is subject to high intensity storms as shown by recorded 24-hour rainfall of 9.90 inches at Lebo, Kans., in 1928; 9.65 inches at Osage City, Kans., in 1909; and 7.00 inches at Appleton City, Mo., in 1943. Most of the water during the high intensity storms rushes off in streams and causes serious land and sediment damage. The greatest number of the very intense rains occur during March through June.

The unprecedented flood on the lower Missouri River in July 1951 was the greatest in more than a century, with the Osage River one of the important contributors.

#### SOILS

Most of the soils of the Ozark highlands are light colored, formed under forest conditions. On the steep slopes, the soils are shallow to bedrock and very stony or cherty throughout. They have very low water-holding capacity and fertility. These areas are suitable only for timber production and permanent pasture. Erosion is slight to moderate. The smooth ridges, which, in a few places, are fairly wide, have a silty surface layer. Here, although the soils are low in organic matter and fertility, they are suitable for cropland and are moderately productive. The soils of the flood plain, however, are the most productive in the Ozark highlands.

Dark-colored grassland soils dominate the central prairie. They have formed from weathered shales, sandstones, and limestones. The soils in general are fairly deep to bedrock, slowly permeable, medium-textured, and moderately productive. Many of them on the level upland areas have heavy, clayey subsoils—claypans. The majority of the soils of the central prairie have a wide range of use and adaptability. The limitations are largely slow permeability, limited water-holding capacity, slow infiltration, and susceptibility to erosion when intensively cultivated. The soils are moderately eroded throughout most of the area. In places, they are severely eroded.

#### NATURAL VEGETATION

The native vegetation of the eastern part of the watershed, the Ozark highlands area, consists chiefly of hickory, several species of oak, and associated forest types. In the central prairies, the native vegetation is largely tall grasses (bluestem, needlegrass, wheatgrass, and sandgrass) with bottom land—mixed hardwood forest cover bordering many of the streams.



## ECONOMIC DEVELOPMENT

The area included in the Osage watershed is a relatively densely settled farming area. The economy rests heavily on income from livestock farming. While it is a fringe area of the Corn Belt, productivity is somewhat less than the average of Corn-Belt land.

The total population of the Osage River watershed, based on the United States census of 1940, is approximately 378,000, of which 107,000 are urban, living in towns of 500 or more. The largest towns are Fort Scott, Kans. (population 10,557); Ottawa, Kans. (10,193); Nevada, Mo. (8,181); and Clinton, Mo. (6,041). These towns are, primarily, marketing and distributing centers for their trade areas. Most of the manufacturing enterprises are engaged in processing agricultural products. The value of all manufactured products is about 25 percent of the value of farm products.

The watershed is well served with a network of Federal, State, and county highways and roads. Six railroad transportation systems are ample to meet the present needs of the area. While the Osage River is considered navigable from the mouth to a point just below Warsaw, Mo., water transportation is limited and of minor importance.

The Bagnell Dam and Reservoir are located on the main stream. This is a hydroelectric development operated by the Union Electric Co. of St. Louis, Mo., which provides electric power for a large population.

The watershed is largely utilized in agriculture with 86 percent of the land in farms. Most of the privately owned land not in farms occurs in the Ozarks and is utilized for forest and recreational purposes. The type of farming throughout the watershed is general livestock. There is a large variation in both use of land and income from the land. About 90 percent of the farm income is from the sale of livestock and livestock products.

Generally the incomes of farms are low in the eastern part of the watershed. The per acre gross income in the rough, hilly eastern area ranged from \$6 to \$10 per acre in 1944. The income in the moderately rolling prairies was double this amount. From 26 to 50 percent of the farms in the Missouri portion of the watershed had incomes of less than \$1,500 in 1944. Many of the operators in this area are only partially dependent on the farm for their livelihood. Also, there are a considerable number of small-scale, low-income farms with little or no nonfarm income. These small-scale farms are characterized by small investment in livestock and inadequate equipment.

Agriculture in most of the western part of the watershed, the rolling prairies, is largely commercial livestock farming. A large part of the total farm income of the watershed (\$65 million from the sale of livestock and livestock products, crops, and forest products, 1945 census) is from the farms in this area. The income from the sale of crops is more important in this area than in the eastern part of the watershed. The farms are comparatively well equipped and represent relatively large investments in real estate, livestock, and farm equipment.

Approximately two-fifths of the agricultural land of the watershed is cropland, about one-third is in permanent pastures, one-fourth is in forest land, and 2 percent is in brush. Of the total cropland in the watershed, 33 percent is in intertilled crops such as corn, sorghum,



and soybeans; 30 percent in small grain such as wheat and oats, etc., and 37 percent is in hay or rotation pasture.

There is wide variation in the use of agricultural land throughout the watershed. The rough and hilly eastern part of the watershed is largely in permanent land cover. Approximately one-half is in forest, one-fourth in pasture, and one-fourth in cropland. The central prairie area, comprising about 54 percent of the entire watershed, is used much more intensively. Over one-half is cropland, most of the rest is permanent pasture, and less than 6 percent is farm forest land.

#### PATTERN OF LANDOWNERSHIP AND TENURE

Nearly all of the area of the Osage River watershed is held in private ownership. Only about 25 square miles of land is publicly owned, most of which is owned by the States.

There are approximately 64,800 farms in the watershed and these average about 151 acres in size. The average farm is somewhat greater in size in the western part of the watershed than in the Ozark border area. Tenancy averages about 18 percent in the eastern part of the watershed and about 32 percent in the moderately rolling prairies.

#### CROPLAND

Much of the cropland throughout the watershed has been farmed for many years without support of conservation practices such as terraces, contouring, and proper water-disposal systems. This has resulted in considerable sheet and gully erosion which was accompanied by loss of soil productivity, land destruction, and land depreciation. Many crop fields, especially in the moderately sloping prairies, have been subdivided by gullies into small fields difficult to till. Others have been gullied to the extent that it is no longer feasible to crop them. As a result, they have been put to a lower income-producing use, i. e., pasture or woodland.

There is a considerable variation in the use of cropland from east to west. In the rough, hilly eastern area about 24 percent of the cropland is in intertilled crops, 24 percent in small grain, and 52 percent in hay and rotation pasture. In the moderately sloping prairie area, much more of the cropland is used for intertilled and small-grain crops. Approximately 37 percent is in intertilled crops, 32 percent in small grain, and 31 percent in meadow. The northern part of this area has a slightly greater portion of the cropland in intertilled and small grains than the southern part.

In general, much of the cropland throughout the watershed is producing far below its capacity because of the lack of crop rotations adapted to the capability of the land, and because of the inadequate use of soil amendments such as commercial fertilizers and lime. The lack of proper proportion of deep-rooted legumes and suitable grasses has impaired the soil structure to the extent that crop yields are reduced because of inadequate aeration. In addition, impairment of soil structure has affected infiltration and soil permeability unfavorably which, in turn, increased runoff, erosion, and the sediment load of streams. The rate of infiltration is of major importance in the rate of surface-water runoff, sediment rate, and erosion damage throughout the watershed. It is of greatest importance in the moderately sloping

headwaters area in which 57 percent of the land is cropped and where the soils in their natural state were only slowly permeable.

At present, over 75 percent of the hay and rotation pasture is classified as poor. This condition is not only conducive to excessive runoff, erosion, and sediment production, but results in poor quality livestock feed and low per acre income. Inasmuch as over 14 percent of the watershed is in hay and rotation pasture, the effect of poor meadows on farm income is important.

#### PASTURE LAND

On about 75 percent of the pasture land, the cover is so inadequate as to be classified as poor, both from the standpoint of runoff and erosion control, and the production of a satisfactory quantity and quality of grazing. These pastures have been rather continuously overgrazed and otherwise poorly managed for many years, which has resulted in their present poor hydrologic and productive condition. In general, the pastures throughout the watershed are producing less than one-half the forage that can be attained under proper management practices. The contribution of poor pastures to flood, erosion, and sediment damage is important inasmuch as 32 percent of the land area is in permanent pasture. An important part of the farm income in the watershed is derived from grazing animals, consequently low productivity of the pastures has an important effect on the present level of farm income.

#### FOREST LAND

Forests are significant to the economy of the Osage River watershed. The present stands in the Ozark highlands are considerably inferior to the original forest, both as to volume and quality. This decline has been due to overcutting, repeated burning, grazing, and attempts at land clearing. Practically all of the forest lands are privately owned. There are no Federal forests in the watershed, and the State forest area is small, amounting to approximately 16,000 acres. Much of forested area in the Ozark highlands and almost all of that in the central prairies is in farm forest.

Forest cover is important to the regulation of stream flow and the prevention of erosion and reduction of sedimentation. In many areas in the Ozark highlands, the forests are more important for watershed protection than for timber production, grazing, or any other use. In certain areas the cutting of timber on the steeper slopes may disturb the soil to such an extent as to create flood and silt problems. The present poor condition of the forests in the Ozark highlands has had a detrimental effect upon stream flow. There in the poorly managed forests the compact soil surface, with little or no humus and protective litter, causes great surface runoff during high precipitation periods and low stream flow during droughts. The ground-water supply has also declined because there is little recharge from the abused areas. In numerous areas of the central prairies, the stream regimen has been seriously disrupted by misuse of the forest areas adjacent to the stream channels.

Timber contributes only a fraction of what it could to the development and stability of the watershed economy. As a result of overuse and abuse during the past century, the quantity of larger trees and

better species has gradually diminished. Considering the quality as well as the over-all available timber, the timber requirements far exceed the local supply.

Grazing of livestock on more than 80 percent of the watershed forest land has created serious conflicts with other uses such as watershed protection and timber production. Generally speaking, livestock use should be limited to pasture and certain open forest types. Livestock should be excluded from the more valuable timber types and from critical watershed lands.

Trees have been used as a protective cover for homesites, field windbreaks, and hedges since early settlement times. Interest in windbreak planting is great throughout the central prairie area.

#### FISH AND WILDLIFE

The watershed has numerous kinds of wildlife which provide good hunting. Native game includes deer, squirrel, rabbit, quail, wild turkey, and ducks and other migratory waterfowl. Introduced game includes the Chinese pheasant which has been successfully established in many farm areas. Bass, sunfish, perch, catfish, and crappie are common and provide good fishing.

The production of fish and wildlife is far below the potential in the watershed. In many localities, the continuous abuse and mismanagement of land, without consideration for the wildlife resource, has been detrimental to game and fish. Widespread burning, grazing, and overcutting of forest cover, indiscriminate use of cultural methods of weed and brush control, burning of pastures, burning and clearing of fence rows, and the lack of conservation-farming methods in general have destroyed or radically changed cover, increased sediment load in streams and caused wide fluctuations in stream flow. These adverse watershed conditions, by radically changing habitats, have been particularly damaging to the fish and wildlife population and, in many cases, have caused an increase in less desirable species accompanied by a decrease in the more desirable ones.

#### RECREATION

The forested Ozark highlands, especially those in the Lake-of-the-Ozark region, provide recreational opportunities that are enjoyed by those living relatively short distances away. The large population centers of nearby Kansas City, St. Louis, and other large urban populations in and near the watershed use this area for picnicking, hiking, hunting, and fishing. Although a given phase of recreational use may be seasonal, the type of recreation varies to such an extent that the facilities are used practically year around. Forest fires, soil erosion, overcutting, and other destructive elements have impaired the natural beauty of the wooded hills and streams and reduced the attractiveness to hunters, fishermen, and tourists.

#### WATERSHED PROBLEMS

##### RESOURCE DETERIORATION

Soil erosion has removed approximately 41 percent of the topsoil from fields that have been cultivated and the productive capacity



has been reduced markedly. This is particularly significant in this relatively densely settled area where such a large part of the population is dependent upon the land for a livelihood. It is significant to the Nation also because of dependence on production from this and similar areas to meet increasing demands for food.

If increased demands for food are to be met, productive land resources will be under still greater pressure of intensive use. This means that the intensity of application of conservation measures must also be applied to hold the land resources.

Associated with accelerated erosion and loss of soil productivity has come an increase in frequency and severity of floods. If we are to meet this problem, there must be an acceleration in the application of measures on the lands of the watersheds that will hold the soil and retard the runoff.

The accelerated erosion and uncontrolled runoff resulting from misuse and mismanagement of the watershed have increased flood damage to agriculture, urban, and industrial developments throughout the watershed. A major portion of the total agricultural damage occurs on tributary watersheds and subwatersheds of tributaries. Based on an analysis of available flood records for the past 30 years, damaging flood stages occurred on the average of three times annually. Since 1941, tributary watersheds have been subjected to a particularly severe flood cycle. During this period, annual floodwater damage has been twice the average and practically all tributaries have had their greatest floods.

Forests possess resources which can be used for multiple purposes. In order to obtain maximum benefits and to prevent serious injury to these resources, the multiple uses must be closely correlated and balanced. The goal in management is to conserve the resources and enhance the usefulness of the land. This can be accomplished through such measures as adequate fire protection; tree planting; stand improvement consisting of pruning, thinning, release cutting, selective cutting of merchantable trees, and conservative grazing.

Originally, the Ozark highlands were almost completely forested. Clearing for agricultural purposes, fire, grazing, and timber cutting have so impaired the absorptive capacity of the soil that storms of long duration produce a large amount of runoff. High-intensity storms, characteristic of this area, produce rapid runoff from the hilly, thin soils. Flood flows in the Ozarks are usually flashy and streams seldom remain above flood stage for more than 24 to 48 hours. Steep stream gradients producing high-velocity flows contribute greatly to land damage on the flood plain. The flood plains, especially the tributary flood plains, have light-textured, shallow, but productive and intensively farmed soils. The high-velocity flows result in much scour and streambank erosion. These high-velocity flows spew out infertile cherty, sandy and gravelly material on the flood plains. A large acreage of the flood plain has been rendered unsuitable for cultivation, and some of the land has been damaged to the extent that it is no longer fit for agricultural use of any form. These high-velocity flows also contribute importantly to the damage to transportation facilities.

Most of the western part of the watershed, the rolling prairie area, has medium to slowly permeable upland soils which are largely under cultivation. These conditions are conducive to a large volume of

runoff. High-velocity runoff, especially during intensive and prolonged spring and summer storms, causes tributary floods on the average of once or twice a year. Normally, flood duration on tributaries does not exceed 12 to 36 hours. The stream gradients are low, and the bottom-land soils are more resistant to erosion than the flood plains of the Ozark tributaries. Misuse of the uplands in this area has accelerated erosion to the extent that sheet and gully erosion have damaged productivity of the uplands and increased the sediment load of streams. A considerable acreage of land has been removed from production or put to a lower income-producing use because of gullying. Deposition of heavy clay materials from sheet and gully erosion has contributed importantly to the impairment of drainage on the flood plain. This type of damage is of particular importance on the major tributaries and the main stream in the central-western part of the watershed. Sediment originating in this area is an important source of sediment damage to reservoirs.

Approximately 197,000 acres along the main stem of the Osage River and 231,000 acres along its major tributaries are subject to floodwater and sediment damage. In addition, a large acreage in the subwatersheds of tributaries is subject to very frequent flooding. On the average, flooding of this land occurs one or more times annually. Most of this land is highly productive and used for crop and pasture production.

The wide, intensively farmed flood plain of the main stream in Kansas is very highly productive land on which many valuable farm improvements are located. The main-stem flood plain from the State line to Taberville, Mo., is wide; however, the soil is poorly drained, heavy-textured and frequently flooded. These conditions result in a low level of agricultural production. Between Taberville and the upper end of the Lake of the Ozarks, the flood plain is narrow, soils are of medium productivity, and few farm improvements are located on the flood plain. Below Bagnell Dam, the flood-plain land is medium productive.

Most of the alluvial soils of the tributaries are of good to superior productivity; however, a large part of the bottom land below Urich, on the South Grand River, is poor and in low level of agricultural use. Flood plains of the tributaries in the Ozarks are generally narrow but highly productive. Good cropland in the Ozarks is scarce so these flood plains are farmed intensively and provide an important part of the total production from cultivated land in the area. Many towns and villages are subject to flood damage. Ottawa, Fort Scott, and Osawattamie are subject to severe damage. Numerous highways, six railroads, and public utility property are subject to damage. The hydroelectric plant at Bagnell Dam, Lake of the Ozarks, and developments along the shore line of this lake are subject to damage. Four run-of-river hydroelectric plants are also subject to damage.

#### CHARACTER AND EXTENT OF FLOODWATER AND SEDIMENT DAMAGE

The estimated average annual erosion, inundation, and sediment damages are shown in table 1. These estimates include both direct and indirect damages that will be affected by the recommended program for watersheds draining less than 3,000 square miles. These damages occur on the upland and flood plains of the main streams, tributary



streams and minor watercourses. They include damages to existing reservoirs, including the Lake of the Ozarks. No damage estimates are included for those areas protected by existing reservoirs.

In addition to direct and obviously damaging effects of floodwater, numerous indirect losses are incurred. These are real losses but are less obvious and more difficult to evaluate than the direct damage caused by inundation and sediment.

Among the more evident forms of indirect flood and sediment damages are included the disruption of normal activity both in the flooded area and in the surrounding region; loss of farm wages; loss in weight and condition of livestock; spreading of disease and noxious weeds; decrease in land values; decreased efficiency in use of labor and machinery; delay and inconvenience to travelers; increase in highway accidents; and countless other social and economic disturbances within the flooded area.

Of the total damage in the watershed, as evaluated in this report, 33 percent is inundation damage, 49 percent land damage, and 18 percent sediment damage.

#### *Land damage*

*Sheet erosion.*—Sheet erosion, the removal of the surface of land by overland flow of water, has removed large quantities of fertile surface soil causing sediment damage and permanently reducing productivity of the uplands. Effects of sediment produced by sheet erosion is evaluated under sediment damages. Damage to the upland soil resource resulting from sheet erosion has not been evaluated due to lack of time and funds, although this is one of the greatest sources of damage in the watershed. It is believed to be in excess of \$1½ million annually.

*Gully erosion and land depreciation.*—Gullies have damaged an estimated 220,000 acres of productive upland. A much larger acreage has been depreciated because of dissection of crop fields causing abandonment for lower income-producing uses such as pasture and woodland. Prior to abandonment, a large loss of income has occurred as a result of increased farm operating costs on the dissected crop fields. Loss of income due to land depreciation by gully formation amounts to approximately one-half of the total erosion damage evaluated, and is about twice the loss due to land actually avoided by gullies. Most of the gully damage occurs in the rolling central prairie area where gullies are more prevalent and damageable values are highest.

*Stream-bank erosion.*—Stream-bank erosion has removed from production an estimated 14,700 acres of bottom land. It occurs throughout the watershed although somewhat more severe in the Ozark area where about 60 percent of the damage occurs. Cutting of timber originally protecting the stream banks has accelerated stream-bank erosion markedly.

*Flood-plain scour.*—Damage by flood-plain scour is prevalent throughout the watershed with about 58 percent occurring in the hilly Ozark area where frequent flood flows erode the shallow, light-textured, intensively farmed, alluvial soils. A large acreage has been scoured to the extent that all soil has been removed, leaving gravelly material exposed which is unfit for crop or pasture production. In the central prairies the gradient of the tributary streams is somewhat lower and the heavier soils are more resistant to scouring. An esti-



mated 175,000 acres of flood plain have been damaged, reducing production an average of 36 percent.

### *Sediment damage*

The products of soil erosion impair productivity of bottom lands, reduce storage capacity of reservoirs, and damage transportation facilities. The principal source of harmful sediment is sheet erosion with gully erosion, stream-bank erosion, and flood-plain scour contributing to a lesser degree. Harmful sediment is constantly reducing the productive capacity of the flood plain and steadily decreasing the income from this land.

*Infertile overwash.*—Infertile overwash, the deposition of less fertile sediment on bottom-land soils, has damaged more than 46,000 acres of bottom land, reducing production about 17 percent.

*Swamping.*—Swamping damage occurs primarily in the western and central parts of the watershed. Approximately 81,500 acres of bottom land have suffered an average of 20 percent loss in productivity. This damage results from sediment deposits in channels and on flood plains. Material deposited in channels raises the water table, and deposition adjacent to stream channels forms natural levees obstructing surface drainage from flood-plain land. Clay and silty deposits have progressively impaired internal drainage.

*Drainage ditches.*—Drainage ditches in the western part of the watershed have been damaged by sediment filling the channels. This deposition increases the cost of maintaining drainage installations and impairs their usefulness.

*Reservoirs (existing).*—Reservoirs throughout the watershed are being damaged through loss of storage capacity by sedimentation. The Lake of the Ozarks, the reservoir for the hydroelectric plant at Bagnell Dam, is losing capacity through sedimentation at the rate of 0.34 percent annually. A total of 5.78 percent of the capacity has been lost since completion in 1931. Continued sedimentation will reduce the effective life of the reservoir, reduce its power-producing potential, and impair its recreational value. One hundred and seven smaller lakes and reservoirs with drainage areas in excess of 160 acres are losing capacity through sedimentation, many of them at much greater rates. They include water supply, recreational, power, and farm reservoirs.

*Water-treatment costs.*—Water-treatment costs for municipal water supplies are increasing because of filtration of suspended sediment. Seventeen cities and villages are adversely affected by the sediment load of streams.

*Transportation facilities.*—Transportation facilities consisting of approximately 1,500 miles of railroads and 28,000 miles of State, county, and local roads are damaged by sediment. Removal of sediment deposits from highways and railway ditches and culverts, and from roadbeds, greatly increases the cost of maintaining these facilities.

### *Inundation damage*

*Agricultural.*—Agricultural damage consists of damage to crops; pastures; and farm improvements, including farm buildings and contents; fences; farm roads and bridges; farm water supplies; farm machinery; and livestock. Inundation of crops, comprising the major

portion of agricultural damage, results in either reduction in yields or losses sustained by replanting the field with the same crop or an alternate crop. Frequently, the planting is delayed by floods until normal yields can no longer be expected. Replanting is common and results in increased production costs and usually a reduction in net income. The grazing capacity of pastures is greatly reduced by inundation exceeding 24 hours. Pastures are frequently damaged by silt. Normally, pasture damage is more serious on the main streams.

Debris is often deposited on cropland which must be removed prior to planting. Fence damage is widespread resulting in large expenditures for labor, material, repairs, and replacement somewhere in the watershed every year. Broken fences cause temporary loss of pasture and livestock damage to crops.

*Nonagricultural.*—Nonagricultural damage includes inundation of State, county, and local roads and bridges, railway fills and bridges, and public utilities such as telephone and electric power installations. County and local roads and bridges are particularly vulnerable to inundation damage. They are generally not designed to withstand unusual floods. The repair of these local transportation facilities is often delayed because of lack of funds which materially adds to damage and inconvenience.

#### *Other damages*

In addition to the evaluated floodwater and sediment damages are interruptions in trade, transportation and manufacturing, costs of flood relief, cost of policing, sanitation, and restoration of public works, and other demands on public funds and services. In 1951 these damages have been very large at Fort Scott, Ottawa, and other towns located on the upper flood plain. Equally important are losses from migration, decadence, stagnation, and impoverishment in rural areas and sections of cities, disruption of schools and other public institutions, and general dislocations in social and economic relations. Also, loss of life, loss of irreplaceable reservoir sites, aggravated illness, and other flood disasters may occur. The most common and formidable pest of man and livestock in the Missouri Basin is the floodwater mosquito (*Aedes vexans*) produced in prodigious numbers as a result of flooding. These damages along with damage to fish and wildlife and recreational values have not been evaluated in monetary terms.

The Bagnell Dam and Reservoir, a large hydroelectric installation on the main stream, represents a large investment and an important source of electric power for the region. The useful life of the reservoir will be lengthened by installing the runoff and water-flow retardation and erosion-control features of the recommended program.

The installation of the recommended program will reduce the rate at which the reservoirs proposed by the Corps of Engineers will fill with sediment. There are nine reservoirs proposed in this watershed by the Corps of Engineers, representing a large public investment (Review report, Osage River, Mo. and Kans., January 1948, Kansas City district, Corps of Engineers).

TABLE 1.—Average annual flood damage, Osage River watershed

[Long-term projected prices]

Type of damage	Average annual damage
Land damage: <sup>1</sup>	
Gully erosion.....	\$2, 792, 600
Stream-bank erosion.....	155, 800
Flood-plain scour.....	382, 800
Subtotal.....	3, 331, 200
Inundation damage:	
Agricultural.....	1, 642, 200
Nonagricultural.....	611, 800
Subtotal.....	2, 254, 000
Sediment damage:	
Bottom land (infertile overwash, swamping and drainage ditches).....	328, 700
Reservoirs (existing).....	232, 400
Water-treatment costs.....	39, 400
Transportation facilities.....	792, 800
Subtotal.....	1, 393, 300
Total.....	6, 978, 500

<sup>1</sup> This does not include damage to upland soil resources resulting from sheet erosion.

## PROGRAM PARTICIPATION

Installation of the program for improvement of the farm and forest land in the watershed entails sizable investments for farm owners and operators. Part of the returns from much of the investment will accrue from increased production from soil, forest, and other resources, and will be shared by many, including the original investor, the ensuing landowners, off-farm interests, and future generations. Some returns will require a period of waiting. There are opportunities for investment in permanent improvements which will provide nearly immediate cash return, which may cause some farm owners and operators to be reluctant to bear a large share of the cost of installing those measures which may not yield returns at a rate sufficient to amortize the investment during their period of occupancy. The public must bear an equitable share of the cost of installing measures having benefits in the public interest. At the same time landowners and operators, as individuals and as organized groups, will have responsibility for protecting the joint private and public investments. For example, the attainment of adequate forest-fire protection is hampered considerably because there are no legal restrictions concerning the burning of land by landowners. It is a prevailing practice in the Ozark highlands to burn forest cover to produce grass for grazing purposes. In many areas, the area burned annually by these so-called legal fires is greater than that burned by all other causes combined. Public regulation of burning, cutting, and other forest practices to stop forest destruction and deterioration on private lands is recognized as a possible element in an adequate private forestry program. However, because additional legislation would be required, this measure is not included in the recommended program.

The recommended program will greatly increase the production of livestock feed crops throughout the watershed. To utilize the in-



creased production, additional investment in livestock will be required. In some cases, the improved farming methods, along with the increased feed production and livestock numbers resulting therefrom, will require additional investment in buildings and farm equipment. Even though the returns on the investments yielding the increased crop and pasture production is realized nearly immediately, the acquisition of the capital needed for machinery and livestock investments may be difficult for some farmers, especially the small-scale farmers and many livestock-share tenants and young farmers who have not yet accumulated working capital of their own.

The grazing of livestock on the forested areas has supplemented farm income in some areas. Since the recommended program provides for the protection of forest lands from grazing, the supplemental farm income from this source will be reduced where forest grazing is extensive. However, the increased production on the open land resulting from the recommended program is expected to more than offset the immediate reduction of farm income due to the elimination of forest grazing. The increased production and the improved quality of timber resulting from grazing and fire protection will substantially increase the future incomes from the farm forests.

The recommended accelerated rate of installing the program is dependent upon active participation of farm families and farm groups in cooperation with the organized agencies, both governmental and civic, who are working in the area. Such participation and cooperation can be secured only through widespread knowledge of the objectives of the program and a definite and clear understanding of the practices to be applied in carrying out the program. The best means of achieving these is through education. Cooperative participation in the program, efficient utilization of technical services and other public assistance in installing the program, and proper maintenance is predicated upon timely and adequate educational assistance.

Adequate credit must be available to assure full participation in the program. The land treatment program may create a heavy local demand for loans from agricultural agencies that cannot be met with loan funds currently available for going national programs. The greatest need for credit will be in the eastern hilly part of the Osage watershed where as many as 50 percent of the farm families are reported as possessing uneconomic farm units or underdeveloped land resources and much underemployed family labor. Many families have incomes less than \$1,500 annually. To realize the advantages of the proposed agricultural program, the farmers will require the cash necessary to accomplish the land use changes and to make the recommended adjustments in farm operation. Where farm incomes are relatively low a large portion of the families will have to rely on the credit program of the Department of Agriculture in order to participate in the program, because private credit institutions cannot supply the need. As the demand for loans increases, the Department's credit agencies will request additional loan funds and facilities as required to meet the needs.

The Department of Agriculture will cooperate and consult with local agencies during the planning and installation of the program. Local agencies and individuals will have the responsibility for maintenance of the program and for protection of the public investment therein.

## DESIRABLE PATTERN OF LAND USE

The installation of the total needed program set forth in this report and the attainment of the full benefit that can be expected to accrue therefrom, including increased agricultural production, the stabilization of the soil resource, and reduction of flood and sediment damage, is based on using land in accordance with its capability. The recommended land use is based on reconnaissance conservation surveys and investigations covering the entire watershed. Based on the principles of keeping the land in the most intensive use for which it is suited, consistent with the maintenance of the soil resource, the recommended program includes the conversion of cropland to pasture, forests, and other permanent cover; conversion of pasture to cropland and forests; and conversion of forests to cropland and pasture.

The net effect of placing each acre of the agricultural land in the total watershed in its proper use amounts to a reduction of 6 percent in cropland, an increase of 13 percent in pasture, an increase in total forest land of less than 2 percent, and elimination of brushland. In the eastern hilly border Ozark area, cropland will be reduced about 20 percent, pasture increased 22 percent, and forest reduced slightly. In the sloping prairies, cropland will be reduced slightly and the small amount of forest will be increased about 16 percent.

Improperly managed cropland is generally producing a major portion of the damaging runoff and sediment, and the associated land damage in the watershed. Such land contributes importantly to the inadequacy of agricultural production. It is, therefore, of prime importance that crop rotations which yield the greatest amount of agricultural production consistent with maintenance of the soil resource be installed throughout the watershed. The recommended crop rotations, supported by contouring, terracing, and adequate water-disposal systems, will effect an over-all decrease of 22 percent in intertilled crops, less than 1-percent increase in small grains, and less than 3-percent increase in hay and rotation pasture. The recommended change in the use of cropland in the eastern hilly border Ozarks will amount to a 30-percent reduction in intertilled crops, a 19-percent increase in small grains, and a 4-percent increase in meadow. In the moderately rolling prairies, intertilled crops will be reduced about 17 percent, small grains will be increased slightly; and hay and rotation pasture will be increased about 19 percent.

On nearly every farm there are odd, irregular areas which can be utilized as wildlife areas. Other open areas adjacent to crop, pasture, and forests should be planted to wildlife borders to stabilize the watershed land and provide wildlife habitat.

Present and planned use of agricultural land is shown in table 2.

TABLE 2.—*Use of agricultural land, present and planned, Osage River watershed, Missouri and Kansas*

[Percent]

	Present	Planned
Intertilled crops .....	13.0	10.1
Small-grain crops .....	11.9	12.0
Hay and rotation pasture .....	14.6	15.0
Total cropland .....	39.5	37.1
Pasture .....	32.0	36.2
Forest .....	26.3	26.7
Brush .....	2.2	.....
Total .....	100.0	100.0



## CURRENT STATUS OF WORK

## ACTIVITIES AND ACCOMPLISHMENTS TO DATE

Throughout the watershed, the various agencies of the Department are cooperating with other Federal, State, and local agencies in providing landowners and operators technical services, educational assistance, and direct aids in connection with fulfilling the Federal responsibility for increasing productivity of agriculture and for conservation of the soil, forest, and water resources.

Soil conservation districts are given help in the development of programs for soil and water conservation; improvement and maintenance of soil productivity; and for other activities related to land management. Agencies of the Department of Agriculture, working through soil conservation districts, are assisting individual farmers and groups of farmers in the application of those measures included in the district programs. Soil conservation districts have been established in all counties in the Kansas part of the watershed and in one county in the Missouri portion of the watershed. The total area within soil conservation districts is 4,523 square miles, equivalent to 30 percent of the watershed. Land-management programs have been developed in each of the districts with assistance from Federal and State agencies, including State agricultural colleges and State experiment stations. These districts, organized under State enabling acts, provide local leadership and a legal body through which farmers can work together in establishing soil-conservation practices and improved methods of agricultural production.

In all counties in the watershed, assistance is provided farmers in carrying out practices which will maintain fertility, control erosion, and otherwise conserve our natural resources. Direct financial aid is provided in the amount of approximately 50 percent of the total cost of the practices which have been given prior approval by the local county committees. These payments also serve as an incentive to encourage farmers to carry out additional practices. Since the inception of the program, the annual use of lime has increased tenfold. The use of fertilizer in connection with pasture measures has increased in about the same proportion. Other conservation measures have increased tremendously in their adoption and use, but probably not to the extent which is indicated in connection with lime and fertilizers.

The Department of Agriculture provides financial assistance for cooperative forestry programs administered by the various State agencies. Cooperative activities include forest-fire protection for private lands, technical services to private landowners for the management of their forest land, and making available at nominal cost tree-planting stock for rehabilitation of private forest land. To date such cooperative activity which contributes effectively to flood control in the Osage River watershed has been confined to the State of Missouri. However, only portions of the watershed in this State are under fire protection or receive technical management services.

The State of Missouri administers some 16,000 acres of State park and game lands under management policies consistent with flood-control requirements. Approximately 1,067,000 acres of forest land are receiving some, but inadequate, fire protection; about 300 acres of land are planted annually, and technical services in the improve-



ment of forest cover are provided the owners of about 108,000 acres of forest land.

Conservation educational assistance is provided to landowners and operators and others in the watershed. Information is being supplied as to the manner in which landowners and operators obtaining services and assistance available through the various governmental agencies can contribute to the accomplishment of the over-all objectives of the recommended program. To date, the work is progressing but at a rather slow rate. Only a small part of the work that will ultimately have to be done to install the complete program of land-treatment measures, and especially to install the measures for stabilizing small watercourses, has been done. More intensive conservation educational assistance is required in order to accelerate the acceptance of the complete program for a watershed conservation and improvement program.

#### CURRENT RATE OF PROGRESS

The rate at which the needed measures are being installed under the Department's current programs is increasing. However, installation of measures requiring large capital investment, measures whose benefits are deferred, and measures whose installation require participation of groups of farmers, is lagging far behind the rate necessary to install a complete program of interdependent measures for soil and water conservation. In general, measures for stabilizing small watercourses are not being installed. The current rate of installing outlets and farm waterways, and erosion control structures upon which the sustained effectiveness of contouring, terracing, and other treatment measures are dependent is low. Very few installations are being made in the way of drainage and wildlife plantings. The current rate of installing livestock watering facilities is nearly adequate to meet the requirements of the needed program. It is necessary to accelerate the applications of measures for cropland and pastures, including lime and fertilizers, even though these measures are being applied more rapidly than other measures. The over-all rate of installing measures for crop and pasture lands is about half of that needed.

The going programs on forest land are progressing slowly. In terms of the recommended program, the installation of adequate fire protection is only 44 percent complete. The current rate of tree planting is 300 acres annually, while attention to timber-stand improvement and protection from grazing is negligible. Technical services are available for only 108,000 acres of forest land.

The expenditure for educational assistance needed to accomplish the objectives of the recommended program is about four times the current rate.

#### ESTIMATED TIME REQUIRED TO COMPLETE INSTALLATION OF THE PROGRAM UNDER CURRENT PROGRAMS

At the current rate of progress, 100 years or more will be required to complete installation of the recommended program. The measures on cropland and pasture will be installed in about 70 years, measures on forest lands and measures for the stabilization of small watercourses may not be completed in less than 200 years. At the present time

there are only a few instances where measures for stabilizing small watercourses are being installed.

The number of years required to install individual measures vary greatly. The period required to install measures on cropland ranges from 50 years for terraces to 30 years for fertilization. Most of the measures for pastures will be installed in about 30 years; however, the recommended liming and reseeding will not be completed in less than 40 years. The complete installation of outlets and farm waterways and small erosion-control structures will require 55 years at the current rate of progress, and wildlife plantings will require from 50 to 70 years. The recommended livestock-watering facilities will be completely installed in approximately 22 years under the current programs.

#### ANNUAL EXPENDITURES UNDER CURRENT PROGRAMS

The Federal Government is now <sup>1</sup> spending \$2,810,400 annually in the watershed for those parts of the current program of the Department of Agriculture contributing to objectives of the "total needed" program.

#### TOTAL NEEDED PROGRAM

The "total needed" program embraces the agricultural measures and activities required for the efficient development, utilization, and conservation of land resources of the watershed. It is designed to balance, complement, and support programs and works by all Federal and State agencies for flood control, water-supply development, water-power generation, navigation, and like purposes, and to be carried out concurrently with them. It provides for acceleration of a number of programs and achievements now being carried out in the watershed by the United States Department of Agriculture, land-grant colleges and universities, and other public agencies. It provides for measures not now regularly installed under the Department's current programs that are necessary to complete a balanced program for the watershed. It also provides for effective integration and coordination of these programs and activities.

The "total needed" program is designed to contribute to an efficient and productive agriculture and to fulfill the Federal Government's share of responsibility (1) to preserve, protect, develop, and improve land, water, and forest resources of the watershed by working with farmers and other landowners and operators; (2) to provide technical information and other aids for conservation and management of croplands, grasslands, and forest lands; (3) to help groups of farmers to organize for the installation of effective water and land management in the watershed, and (4) to provide for an equitable sharing of costs between the individual landowner and the public in order to establish the complete program during a 20-year period.

The estimated quantity of measures needed, the installation costs of these measures, and the cost apportionment are shown in table 3. Installation cost shown for each measure includes the cost of direct aids, including the cost of administration necessary to accelerate the program. Costs to be borne by farmers, as set out in the tables, include their out-of-pocket expense plus the estimated value of the

<sup>1</sup> 1950 price level.

farmer's labor; costs of operating machinery, including depreciation; and other expenses. Cost of technical services for crop and pasture land and extension education required to install the program in the specified period are shown as lump sums.

All monetary values in table 4 and throughout the remaining section of this report are long-term projected values. These are based on indexes set forth in the statement of price levels by the Federal Inter-Agency River Basin Committee, Subcommittee on Benefits and Costs, dated August 28, 1951.

The proposed allocation of public costs on forest-land measures is not intended to limit participation of State or local governments in accomplishing these measures. If the States and communities assume a larger share than estimated herein, the Federal cost will be reduced accordingly.

#### CONSERVATION AND IMPROVEMENT MEASURES FOR CROP AND PASTURE LAND

The measures needed on crop and pasture land will provide for land use consistent with conservation of soil resources, and contribute directly to reduction of erosion and control of runoff. Improved agronomic practices, including crop rotations best suited to the land and increased use of fertilizer and lime, are provided to attain this. Supporting practices such as terracing, contouring, and establishment and stabilization of small farm waterways and terrace outlets are included. Some land used for crops will be converted to pasture and forest land, and some depleted pasture land will be converted to forest land.

Application of the measures will be accelerated by extensive education, technical services, and by providing incentive payments, materials, and other services.

#### SEEDING GRASSES AND LEGUMES, AND GREEN MANURE AND COVER CROPS

The initial seedings of 1,777,000 acres of recommended grasses and legumes and 341,000 acres of green manure and cover crops are needed to establish crop rotations adapted to the capability of the land. These seedings will provide the basis for runoff and erosion control and increased productivity on the cropland. Generally, the recommended crop rotations will include meadows with suitable legumes and grasses with abundant root growth to provide the maximum effect on runoff and sediment damage and soil productivity. The establishment of recommended crop rotations will require adequate lime and fertilizers which are included in the recommended program.

#### CONTOUR FARMING PRACTICES

Contour farm operations are needed on 2,538,000 acres of cropland. This includes contouring needed on land to be terraced and on other sloping cropland not requiring or not suited to terracing to support the recommended improved vegetative and fertility practices in controlling runoff and erosion. Contouring will permit more intensive use of cropland than would be possible otherwise and increase crop yields through preventing damage to the crop stand.



## TERRACES

Approximately 151,000 miles of terraces are recommended for construction on cropland which has sufficiently steep or long slopes to produce damaging concentrations and velocities of runoff, and where adequate control cannot be attained through vegetative practices or less intensive mechanical methods. Graded terraces will be used to conduct the surplus water at nonerosive speeds to the stabilized watercourses. Terracing will permit more intensive use of cropland without land deterioration than is possible otherwise. In addition, contour farming operations on the terraced land will increase crop yields by preventing destruction of crop stands.

## SEEDING PASTURES

The establishment of 1,550,000 acres of adapted varieties of legumes and grasses is recommended on land converted to pasture and on pasture land which has been depleted or denuded to the extent that natural processes of revegetation are incapable of restoring suitable vegetation. Fertilizers and lime will be required along with adapted grasses and legume seeding mixtures to establish adequate protection cover on this land. Most of the remaining acreage recommended for pasture use will require renovating with periodic fertilizer and lime applications and legume seedings to improve protective vegetative cover and increase pasture yields sufficiently to provide a practical maximum income from the land.

Improved methods of management on 3,017,600 acres of pasture will greatly improve pastures both from the standpoint of increased production and reduction of runoff and erosion.

## PASTURE CLEARING

The improvement of the carrying capacity of pastures will involve clearing of brush from approximately 260,000 acres.

## FARM PONDS

An estimated 34,300 livestock water ponds need to be developed to provide adequate watering facilities to permit proper distribution of grazing and allow productive use of all pasture lands.

## LIMING AND FERTILIZING

The application of lime on 5,396,600 acres and fertilizer on 5,254,800 acres is needed to obtain proper land use and successful application of soil-conservation measures. Liming and fertilizing cropland is widely practiced throughout the watershed. However, to increase productivity of the land and improve the vegetal cover necessary to reduce runoff and erosion, an increase in rate of application is needed on most farms. In many cases the installation and satisfactory returns from the improved crop rotations will be dependent on increased use of fertilizers and lime. Fertilizers and, in most of the watershed, lime will be needed to adequately establish and improve permanent pastures. The establishment of depleted cropland converted to pasture will require special treatments of fertilizer and lime. Inasmuch as

improvement of existing pastures has lagged considerably throughout the watershed, adequate use of fertilizers and lime on pastures will require public assistance in gaining widespread acceptance.

#### OUTLETS AND WATERWAYS

Approximately 15,600 miles of small grassed waterways are needed to provide for the disposition of surplus water at nonerosive velocities into the subwatershed waterways. Natural waterways will be reshaped and suitable mixtures of sod-forming grasses and desirable legumes will be established. Where fields are terraced, stable outlet channels will be needed. Heavy vegetation may need to be removed to maintain the free flow of water and prevent smothering the sod crops. Lime, fertilizer, and other good fertility practices should be used when needed to establish and maintain a satisfactory vegetal protective cover.

#### EROSION-CONTROL STRUCTURES

Approximately 28,500 small erosion-control structures are needed to stabilize terrace outlets and small vegetated waterways. These structures will include concrete, rubble masonry, or rock dams with earth fill, thereby preventing headward cutting of gullies and field drainage ways.

#### DRAINAGE

Approximately 2,800 miles of farm drainage ditches are needed to permit a more productive use of 150,000 acres of poorly drained land which is producing low crop and pasture yields.

#### WILDLIFE PLANTINGS AND BORDERS

Wildlife plantings will be on 33,000 acres of odd and irregular areas such as fence corners, rough and rocky wasteland to provide wildlife habitat and stabilize land yielding excess runoff and sediment.

Approximately 3,000 miles of wildlife borders will be planted adjacent to crop, pasture, and woodland field boundaries to stabilize the land and to provide wildlife habitat.

#### FENCING RELOCATION

Approximately 24,000 miles of fence will be constructed and relocated on cropland and pasture land to facilitate proper land use, establishment of suitable crop rotations, contour tillage, proper management of pastures, and protection of woodland from grazing. Where practical, living fences will be planted for field divisions and to provide wildlife habitat. Of the above total, approximately 2,900 miles will be living fence. The removal of approximately 2,400 miles of hedge fence is required to facilitate the installation of the total needed program.

#### TECHNICAL ASSISTANCE

Additional technical personnel will be required to help individual farmers and organized groups of landowners and operators to plan and install needed conservation measures. This will involve individual

farms and also the preparation of work plans for watersheds of small streams comprising several farms. Costs of administering the direct aids for crop, pasture, and forests are included in the Federal costs.

### EDUCATIONAL ASSISTANCE

Additional personnel will be required to assist in the organization of soil-conservation districts and other cooperative educational efforts needed to accelerate the application of soil-conservation and forestry measures. The success of the entire program will depend upon voluntary cooperation and the application of all needed measures on a very high proportion of the area of each subwatershed. For these reasons, it is important that unified and concerted educational effort be made a definite part of the total program.

### MEASURES FOR FOREST LAND

The needed program on forest land consists of the following interdependent measures, all of which are essential to comprehensive watershed improvement.

#### ADEQUATE FIRE PROTECTION OF FOREST LAND

Fire protection is a foremost requirement in the rehabilitation and management of forest lands. Without it, other forestry measures are largely ineffectual. In well-protected forest areas, litter accumulations protect and enrich the soil with organic matter, thereby improving the soil structure. In this and other ways, the elimination of fire greatly increases water infiltration and storage. It also reduces damages to timber and prevents the destruction of young seedlings which make future tree crops and sources of litter.

The cooperative fire-protection program between the Federal Government and the States of Kansas and Missouri will strengthen and extend existing fire protection to cover the 2,555,000 acres of private and State forest lands with the objective to limit the annual burn to not more than 0.5 percent of the area.

#### PROTECTION FROM FOREST INSECTS AND DISEASE

There are no major outbreaks of forest insects or disease in the watershed at present. There is no sound basis for predicting such outbreaks nor of estimating the magnitude of control programs which may be needed. As an example, oak wilt is a threat in the watershed for which practical control has not yet been worked out. The recommended program does not include any funds for control measures, but the possibility of future needs for such purposes is recognized.

#### TREE PLANTING FOR COVER RESTORATION AND PRODUCTION OF TIMBER <sup>2</sup>

This measure provides for the restoration of watershed cover on 136,100 acres by planting trees on the poorly protected flood and silt-source lands on which the monetary returns from investments in tree planting are low and deferred for a considerable period of time.

<sup>2</sup> Fencing, ground preparation, and cultivation are not included in tree planting costs in this watershed. This and differences in character of plantations account for wide differences in costs per acre for tree planting in the various sections of this report.



The establishment of trees provides an effective means of restoring good hydrologic conditions on these forest lands. Within 5 to 10 years the soil movement can be largely halted and water infiltration substantially increased.

Provisions are also made for the planting of trees on an additional 168,000 acres to increase the supply of merchantable timber for future use. Existing stands on this acreage consist primarily of inferior species and trees of poor quality which have little or no value for wood products.

#### PROTECTION FROM GRAZING OF FARM FOREST LAND

Forest land must be protected from livestock grazing to insure establishment of young trees, to retard runoff, to control erosion, and to reduce sediment from forested areas. Elimination of grazing facilitates the restoration of the soil structure which results in greater infiltration and resistance to erosion.

This measure involves, when necessary for the protection of farm forest areas, the construction of new fence to replace old fence in extremely poor repair, and the provision for rearrangement of pasture boundaries.

#### NURSERIES

The present supply of nursery stock for planting is limited to only a fraction of the planting needs. Some 12,000,000 to 15,000,000 seedlings will be planted annually. One nursery will be built and one nearby State nursery will be enlarged to furnish the additional planting stock.

#### TIMBER STAND IMPROVEMENT

Provisions are made for the removal of competitive vegetation and the application of other precautionary measures in newly planted areas in order to assure the continuous growth of the young trees. Silvicultural measures—thinning, pruning, and release cutting—will be undertaken in a few of the older stands to increase the growth and quality of the more valuable species.

#### FOREST STREAM IMPROVEMENTS

Improvements can be made in some of the streams for fish life. The necessary work would include the installation of deflector bars which form pools and ripples for aeration.

#### PUBLIC ACQUISITION OF FOREST LANDS

There are 675,000 acres of badly deteriorated forest land in the Ozark highland area where the necessary investments may not be made to protect and improve the forest resources unless they are in public ownership. These lands inherently possess relatively low productive capacity which has further deteriorated from poor land management practices, destructive influences of fire, and loss of topsoil by erosion. The costs for the improvement of the land and the betterment of the forest resources will be high while the returns will be deferred for an extended period of years and the rate of earnings will be low in com-

parison with other forest lands and other sources of investment available to private capital.

The estimated cost to acquire these lands, projected on future price levels, total approximately \$5,690,000. The cost of restoration and development would be approximately \$5,200,000 after the lands are acquired.

### MEASURES FOR STABILIZING SMALL WATERCOURSES

The needed measures consist of interrelated and interdependent measures which should be installed concurrently on minor watersheds in proper combination and sequence with land use and conservation practices on crop, grass, and forest land to attain most effectively and economically the objective of soil and water conservation and reduction of erosion, inundation, and sediment damages.

Reduction of erosion damage, abatement of inundation and sediment damages, and continued maintenance and improvement of land and water resources of the watershed are possible through proper integration and timeliness of installation of practices and measures recommended. The recommended program in its entirety is formulated to increase the intake of water into the soil, retard movement of water that is not absorbed, and lead water that is neither retarded nor absorbed along its least damaging route to the major rivers.

The intensity of numerous rains will exceed infiltration capacities of the soils of the watershed and runoff of flood-forming proportions will occur regardless of the use and treatment of the land. This excess runoff must be conducted to the main streams in an orderly manner if erosion damage is to be reduced and downstream inundation and sediment damages abated.

The realization of the full benefit of installing measures for stabilizing small watercourses is dependent on installing land-treatment and conservation measures. However, insofar as practical, these measures have been evaluated independently of land-treatment measures and only measures adjudged economically feasible are included in the recommended accelerated program.

### RECOMMENDED STABILIZING MEASURES

The measures needed for stabilizing small watercourses have these characteristics:

Their primary purpose is to stabilize minor waterways and tributary streams and to provide for orderly water disposal and sediment control as an essential part of a complete and integral program of runoff and water-flow retardation and soil-erosion prevention. These measures reduce flood and sediment damages, maintain land resources, and protect water-resource developments in the watershed against impairment by sedimentation.

Public and private benefits accrue from these measures and also produce substantial contributions to sound land use.

Groups of landowners and operators, as well as local agencies of government with common interests, are involved in protecting minor watershed units.

Benefits from these measures justify substantial public expenditures in technical and other assistance.

The recommended measures for stabilizing small watercourses include establishment of:

#### *Upstream floodwater-retarding structures*

Approximately 300 upstream floodwater-retarding structures are recommended. These structures, by providing temporary storage, will reduce flood damages caused by runoff in excess of that which can be controlled by land-use and conservation practices recommended herein. In addition, installation of these structures will permit more intensive agricultural use of bottom lands. Areas of land now used for pasture because of flood hazards may be utilized for crop production. The effect of the structure on stream flow diminishes progressively downstream from the site.

These structures are of the "dry" type and will be located at sites where the temporary impoundment of water will cause a minimum reduction in productivity in the reservoir area. The principal type of structure recommended is a small earth-fill dam with an outlet to release water at a fixed and safe rate, and a spillway adapted to site conditions. The structures are designed to retard approximately 3 inches of runoff. Drainage areas above the structures range up to 5 square miles.

#### *Tributary channel improvement*

Approximately 200 miles of small-stream channel improvement by stabilizing banks, removing obstructions, and installing other protective measures are recommended.

Channel improvement is needed in many parts of the watershed to stabilize stream banks and thereby reduce erosion damage from stream bank cutting and flood plain scour as well as the accompanying down-stream damage from sediment. The recommended improvement will also increase channel efficiency. These damages cannot be rectified by land use and conservation practices alone. The measures include vegetation and structures adaptable to the conditions encountered. The channel improvement recommended is generally limited to control measures on streams draining less than 100 square miles. These works will be installed at sites providing protection for valuable cropland, highways, railroads, bridges, utilities, farm buildings, and other high value improvements.

#### *Stabilizing and sediment-control structures*

Approximately 28,500 stabilizing structures are recommended. These structures will stabilize gradients of upstream channels and will reduce head cutting of gullies that are destroying and depreciating land values and producing harmful sediment. The principal types of structure to be installed are drop inlets, chutes, culverts, and drop spillways. The structures should be installed in proper sequence and combination, with the recommended land treatment. Generally, only part of the total benefit of these structures will accrue to the owner of the land on which they are installed. Thus their installation and maintenance will usually involve participation of a group of landowners.

#### *Subwatershed waterway improvement*

Approximately 12,400 miles of subwatershed waterway improvement to stabilize and protect natural and artificial channels are recom-



mended. These measures include establishment and maintenance of grasses in upland drainage ways, generally those which provide water disposal for a group of farms. The work consists of excavating, shaping, preparing, and seeding of the waterways. Structures needed in conjunction with this vegetative control are included with the recommended stabilizing and sediment-control structures. This work may involve cooperation of several landowners in the minor subwatershed in the same manner as the construction of stabilizing and sediment-control structures.

### *Diversions*

Approximately 3,500 miles of diversions to divert and retard runoff water in order to protect flood plain developments, eroded areas, and terraced lands are recommended. These measures will be used to route runoff water to selected points for disposal, protect severely eroded areas, and direct or retard runoff from severely damaged areas.

## RESEARCH AND SOIL SURVEYS

It is proposed to study the effect of land-use adjustments and watershed treatment on flood reduction, erosion prevention and crop yields in the Osage River Basin.

There is need to measure the results as the program is being applied in order to improve program application in this area and to improve program formulation in other areas.

The cost estimates are for the first 10 years. At the end of that time the recommendations should be reviewed to determine which, if any, of the lines of research should be continued and if any new problems should be studied.

The estimates include only Federal funds. The work will be planned and carried out cooperatively between the United States Department of Agriculture and the State colleges in the respective States. The States will be expected to contribute in accordance with their resources.

## RESEARCH ON CONSERVATION AND MANAGEMENT OF FARM LAND

### *Management and conservation of soil and water*

Limited studies indicate that from 30 to 50 percent of the original nitrogen and organic matter content of most soils of the basin have been lost by decomposition and erosion. Decreased levels of nitrogen and phosphorus tend to limit crop yields in years of favorable rainfall. Infiltration of rainfall is too slow, and too little moisture is stored to supply crop needs. This condition has increased the hazards of runoff and erosion on uplands with subsequent silting of reservoirs, stream beds, and fertile bottom lands. The problem involves the use of contour tillage, terracing, and other mechanical practices as well as finding methods of producing crop cover and methods of providing crop residues to reduce runoff and erosion. Experimental work in the humid region indicates that the use of lime, crop residues, fertilizers, and adapted legumes are promising techniques in making poor and eroded soils produce good crops. To what extent these and other practices are adapted to the reduction of runoff and erosion under the different soil and climatic conditions of the basin is unknown.

The research program will be expanded to include more experimental comparisons in various cropping systems, residue management, tillage, and soil-treatment procedures, depending on the agricultural potentialities of a particular area. The effects will be studied in relation to control of weed growth, water conservation and utilization, crop production and fertility maintenance, and residue control of water erosion. These studies will involve comparisons of the various types of vegetal cover and soil treatments, contour furrows, terraces, and other mechanical devices in reducing erosion and runoff. Methods will be studied for improving the chemical, physical, and biological properties of the soil. Periodic determinations will measure the changes that take place in these properties. Also included will be studies of soil treatments and cultural methods with various legume and nonlegume crops and ways of integrating the use of such crops into good soil-management systems. Special research will be made on methods of improving the productive capacity of badly eroded soils and of preventing further erosion of those soils.

#### *Economic problem of conservation*

Will conservation pay? Conservation is important to the long-run well-being of the Nation. An individual farmer, however, often must judge proposed conservation measures by this year's income. The success of the conservation program depends upon the acceptance of the recommended measures by thousands of landowners and farm operators. Decisions involved in obtaining adoption of conservation land use practices hinge on an analysis of the income from the present way of farming in contrast to returns from recommended conservation practices. Public benefits and costs from conservation farming should be measured. Necessary tenure arrangements and other needed institutional adjustments should be considered. Inducements and incentives may be required to fill the gap between private returns and public benefit if a well-balanced land-conservation program is to be achieved. Studies will be made of the extent landowners and operators can afford to adopt land-conservation measures and the degree to which public assistance is necessary and desirable. Research will include costs and income from various types and combinations of land improvement and conservation measures, public interest in conservation measures on private land, and obstacles to recommended programs. When the Government takes over privately owned land in order to use it for reservoir sites, some farmers have to move, land is taken out of agricultural production, and local communities and local governments are disturbed. A large number of farms are involved in the proposed reservoir sites in the Osage Basin. In some cases, not all of the land within a reservoir area is permanently flooded; part of it may be used for agricultural purposes. These problems will be studied to determine possible opportunities for displaced farmers, how best to use land that is flooded only occasionally, and how to adjust the finances of local governments. The studies will also seek ways of reducing the unfavorable local impacts of reservoirs.

#### FOREST RESEARCH

There are increasing pressures on the forest and forest range lands in the Osage River watershed, particularly those in the Ozark highlands, for many uses. The many problems created by abuse, overuse,

and the conflict of uses are interrelated and complex. As very little forest and forest range research is being conducted in the watershed, and little of that done elsewhere is directly applicable to Osage River watershed conditions, considerable research is needed to determine how best to manage these forest and forest range lands.

Results of much of the research proposed for the Osage should be used as a guide to the efficient management of forest and forest range lands in neighboring watersheds. Thus, the research installations needed in those adjacent areas can be reduced proportionately by virtue of the information obtained on similar lands within the Osage drainage.

#### *Watershed management*

In the Ozark highlands, where the annual precipitation is greater than elsewhere in the watershed, good watershed conditions on the headwater lands are necessary to reduce the frequency and intensity of damaging headwater floods, reduce sedimentation, and maintain plentiful supplies of usable water for domestic, power, navigation, and fish and wildlife and recreation purposes. But due to abuse and overuse, the forest and farm lands are in too poor condition. Instead, they contribute much flood runoff and sediment.

Considerable research, including both long- and short-term studies, is necessary for solving these problems. Of particular importance is the determination of the extent to which several types of vegetation and land use influence the rate at which water enters and percolates through the soil. It is essential to know how much water can be detained in the soil under various types, uses, and treatment of cover. Knowledge is needed as to the amount of water used by the forest and other vegetation. Information is required on the relative rates of soil lost under different forestry and farming practices. It is necessary to determine the combined effects of the individual hydrologic factors affected by forest and other cover and its treatment as expressed in measured stream flow, ground-water levels, sediment production, and precipitation.

#### *Forest land management research*

Overcutting, grazing, burning, and, in some cases, unwise land clearing, have seriously depleted the forest lands, leaving many of them poorly stocked or occupied by almost worthless trees. Preliminary studies indicate that good forest management on a sustained-yield basis can more than double the present yield, both in amount and quantity.

Knowledge is needed on methods of reforesting bare lands and increasing the density of understocked stands to bring these forest lands up to full productivity. The adaptability of various native and introduced forest tree species to various sites and mixtures with other species must be determined, and planting techniques improved. Methods must be developed for converting the low-grade stands of less desirable species to quality stands of more desirable trees. It is necessary to determine the soil, light, water, and other requirements of certain species; and the conditions necessary for the successful establishment of desirable species through regeneration, underplanting, and underseeding intensities. Best frequencies of cuttings, the effects of various logging methods, and how various species respond to treat-



ment must be known in detail before forest management recommendations can be made specific.

#### *Forest grazing management*

The pressure for forage is so great that it has become common practice to graze or pasture woodlands. Due to the conflict between grazing use and timber and watershed values, many questions have been raised about the need and desirability of grazing forest land.

Knowledge of the quantity of forage produced in the grazed forests and the nutritional value of such forest forage in comparison with managed pastures is badly needed. Information is needed on the economics of forest grazing by dairy and beef cattle, hogs, sheep, and goats. The effects of grazing need to be related to timber production, watershed values, recreation, wildlife, and other uses. Investigations are needed to determine the type of grazing use on forest range that will yield the greatest benefits without depleting the forage resource. Ways and means of integrating grazing with other uses must be determined to obtain the greatest benefits from these ranges.

#### *Fire control*

Uncontrolled burning of forests has been a major cause for the poor watershed conditions, lowering of forest site quality, prevention of satisfactory restocking of the stands, a large part of the defect in existing timber, and the great increase in the proportion of less desirable species.

Information is needed as to the extent, type, and dollar value of damage caused by fire to the water, timber, forage, wildlife and recreation resources of the forest and forest range lands. Fire-control tactics must be improved, new and improved fire-fighting equipment developed, and greater accuracy in the prediction of fire weather must be attained.

#### *Forest products*

Aggravated by past abuses of the forest, a great portion of the available timber supply is composed of species of low commercial value, and most of the remaining hardwood stands are comprised of small trees of low quality. Wood waste is a problem, not only in logging, but also in the manufacture of lumber and other wood products. A principal problem concerns the utilization of low quality species which take up growing space yet have a limited use.

New and better ways of using small timber and the less desirable species are much needed to avoid waste and to facilitate stand conversions to more valuable species. To reduce waste and increase income to forest owners, improved techniques must be developed for timber cutting, logging, small mill practices, seasoning, and preservation and utilization.

#### *Forest economics*

A comprehensive inventory of the timber, range, and upstream water resources, the location of problem areas, and the classification of forest and forest range lands according to use capabilities are essential for efficient management and use of the forest and forest range resources. The economics of proper land use and the long- and short-term economic returns to be expected under different systems of management on different classes of forest land must be determined if these

lands are to be brought up to and maintained at high levels of productivity. The effects of tenancy on the management of farm woodlands need to be determined and the problems associated with tenancy have to be solved to insure tenant participation in the farm forestry measures. There is urgent need for the improvement of forest product markets, particularly for the less desirable species, and for the solution of marketing problems so that good forestry may be practiced at a reasonable profit to the owners.

#### RESEARCH ON DRAINAGE DEVELOPMENT

##### *Drainage requirements in relation to soil types and land use*

In the Osage Basin, large areas of comparatively flat land, shallow sloughs, and stream bottoms require artificial drainage before they can be cultivated to the best advantage. Some areas have heavy or claypan subsoils which increase the difficulty of drainage. The operation of reservoirs or construction of levees may interfere with otherwise normal drainage. The problem is to determine drainage requirements under a wide range of soils, climate, and land use and to develop effective methods of drainage under such conditions. The research will undertake to determine the type of drainage needed for different types of land. The feasibility of surface and underdrain for different localities will be studied along with the spacing and size of tile drains. The relation of land use to the system of drainage is another general field of research. Also, research is needed on the relation of flood-control structures to drainage and land use.

##### *Economic problems of drainage development*

Drainage developments are usually financed by assessments against the farm land which is benefited. Many drainage enterprises have encountered economic difficulties in the past. In some cases, the cost of drainage has been too high and farm land has been foreclosed to satisfy bondholders. More often drainage districts have experienced general financial distress which results in a poor credit rating for the farms in the enterprise. As levees and reservoirs for flood protection are installed along the main rivers, local drainage districts will face new problems. Revamping of local drainage systems to conform to new levees and changed stream-flow conditions will throw a heavy burden on land that in some cases is now overburdened with debt. Economic studies will be made of drainage methods, types of organization, types of land involved, costs and returns, and methods of repayment.

#### SOIL SURVEYS AND LAND CLASSIFICATION

In order to provide necessary information regarding the soils of the Osage Basin for programs of land treatment, flood and sediment reduction, drainage, and soil management, either a detailed or semidetailed basic soil survey should be made of each county within the watershed that has not been covered by soil surveys in the past. These counties include Franklin, Osage, Miami, Anderson, and Linn in Kansas, and Vernon, St. Claire, Henry, Benton, Bates, Hickory, Dallas, and Camden in Missouri. Basic soil surveys made by the Soil Conservation Service, cooperating with the State and with the Division of Soil Survey, are in progress in Franklin and Osage Counties in Kansas.

Field work in Franklin County is nearly complete, and in Osage County about 80 percent complete. These two surveys should be finished and published. This will give excellent basic soil data for the entire Osage Basin within a period of 10 years. In the review of this report, it is expected that the States will indicate the proportion of research and soil survey costs to be borne by the States.

### CREDIT

Credit is required in a form and amount suitable to the needs of farm families in making the recommended land use adjustments and installing the recommended conservation practices included in the program. Particularly is this so where major reorganization of farm businesses is involved and where farm family incomes are low.

A demand for loans from agricultural agencies that cannot be met from funds available for going national programs is expected. The Department's agencies will, upon authorization of the program recommended herein, advise the Congress in annual budget submissions of the needs.

### PROGRAM APPRAISAL

#### INCREASED CROP PASTURE AND FOREST PRODUCTION

The installation of the total needed program for cropland and pasture, when fully applied, will increase production of all major crops. Based on feed units, production of cash grain crops will be increased 80 percent, grain feed crops will be increased 23 percent, and hay and pasture will be increased 113 percent. These increases result from the combined effect of changes in land use and increased per acre yields. The acreage of cash grain crops will be decreased about 3 percent, acreage of feed grain crops decreased 14 percent, hay and rotation pasture acreage increased 3 percent, and permanent pasture acreage increased 13 percent.

The per acre increase in crop yields is attributable to improved crop rotations, increased acreage limed and fertilized, increased rates of fertilization, contour cultivation, and conversion of depleted cropland to other uses; thereby limiting the crops to the most productive land. Contour cultivation will increase per acre yields from 15 to 20 percent. The improved crop rotation, containing a greater proportion of meadow to grain, and composed of meadows with deep-rooted legumes and grasses will increase the yields through the addition of organic matter and nitrogen, improved soil structure, tilth, aeration, and drainage. The application of lime to permit the production of improved legumes and the increased use of recommended fertilizers on all cropland when used in combination with proper land use, improved crop rotations, and mechanical erosion control practices, contribute markedly to the expected increase in crop yields. On the average, the annual application of lime will be increased over  $2\frac{1}{2}$  times and fertilizers over 4 times on cropland. Based upon experimental results and field trials, it is estimated that the combined effect of the measures recommended for cropland will increase the per acre yields of corn 12 bushels, sorghum 9 bushels, soybeans 10 bushels, oats 15 bushels, wheat 10 bushels, and hay 0.7 ton.



The measures recommended for pastures are designed to attain a practical maximum yield from all the pasture acreage. The per acre yield of pasture will be increased about 117 percent. This is attributable to the proper application of lime and fertilizers, the seeding of depleted areas, the seeding of more productive grass and legume mixtures, the removal of brush, and the recommended pasture management practices, including deferred and rotation grazing, where applicable. At present, only a small portion of the pasture is adequately limed and fertilized for efficient land utilization. The annual application of lime and fertilizers will be increased about 10 times the present rate on pasture land. In addition, only a small acreage is seeded to improved legumes and grasses. The large acreage of brushy pasture produces very low yields.

Inasmuch as total feed crops (grain, hay, and pasture) will be increased 82 percent, it is expected that livestock production in the watershed will increase markedly. The pattern of livestock may also shift to more roughage consuming livestock. At present, 66 percent of the feed produced is from roughage as compared to 75 percent anticipated when the total needed program is fully applied.

Farm drainage will permit the conversion of 90,000 acres from pasture to cropland and permit more intensive use of the cropland than at present. The improved drainage will increase corn and oats yields 12 bushels per acre, sorghum 6 bushels, wheat 6 bushels, and hay 0.4 ton. The combined effect of the above amounts to an increase in the value of annual production of \$2,132,000, or 122 percent. The conversion of pasture land to cropland and the increase in yields will increase annual production costs \$1,154,400.

Rehabilitated forest lands and forest resources will provide greatly improved hydrologic conditions and will significantly increase the timber supply. Based on available information, it is estimated that the average annual timber growth will rise from 9 cubic feet per acre to about 15 cubic feet when remedial measures are fully effective. These increased timber yields will enhance materially the income of farm families, nonfarm landowners, and timber operators. This will have a considerable stabilizing effect on the economy of those communities which are dependent upon the timber resource. The greater timber production will provide incentive for more local processing and manufacturing, now largely accomplished outside the watershed. Improvement of forests and streams will make more desirable habitats for game, birds, and fish, which, with the improvement of mountain scenery, will foster attractions upon which the important recreation business is based.

#### EFFECT OF PROGRAM ON FLOOD DAMAGE

Reduction of erosion, inundation, and sediment damage in the watershed depends upon the proper integration and the timeliness of installation of practices and measures recommended in this report.

The total needed program, when applied, will increase the intake of water into the soil, retard the movement of runoff that is not absorbed, and lead the water along the least damaging route to major rivers. It will reduce erosion and decrease sediment damage in the watershed.

Many of the measures recommended for the conservation and improvement of crop, pasture, and forest land will contribute to reducing

erosion, inundation, and sediment damages, as well as to increasing production.

Further reduction in these damages is secured by measures and works not ordinarily constructed by individual farmers. The program of stabilizing measures for small watercourses will attain this additional reduction in erosion, inundation, and sediment damages, and make possible the proper installation and continued effectiveness of many of the measures recommended for the conservation and improvement of crop, pasture, and forest land. The program of stabilizing measures for small watercourses will thus complete and round out the total program in aid of flood control.

The installation and proper operation and maintenance of the total needed program will also have the following effect on flood damages: Land damages will be reduced \$2,400,900; inundation damages will be reduced \$367,700; and sediment damages will be reduced \$805,000. Additional benefits will accrue in the form of prevention of sediment damage to reservoirs which are proposed by the Department of the Army, Corps of Engineers. This is estimated to amount to \$94,400 annually.

The program of stabilizing measures for small watercourses includes measures which, in many cases, may afford a degree of protection immediately below the site to the degree that a change in land use will be possible. These changes in land use will increase the value of production from these protected areas by an estimated \$518,000 annually.

#### ECONOMIC JUSTIFICATION

Economic justification in terms of benefit-cost ratios is included for those measures in the recommended accelerated program that contribute to water-flow retardation and prevention of soil erosion.

Benefit-cost ratios for land treatment measures installed in aid of flood prevention are calculated separately from measures for stabilizing small watercourses. This separation in table 5 is for the purpose of analysis. The program can be applied successfully on the land only if all parts of it are authorized and implemented to be carried out as one project in proper sequence and in proper proportions on each farm and each subwatershed. Annual work plans will be prepared for this purpose.

#### *Costs and benefits from land treatment measures*

Quantities and costs of land treatment measures included in the recommended accelerated program are shown in table 5. These include measures for crop, pasture, and forest land.

The average annual equivalent value of the cost of the measures that contribute to water-flow retardation and soil erosion prevention is \$10,833,317.<sup>3</sup> Of this, \$7,805,100 is for annual operation and maintenance to be borne by non-Federal funds, except for a portion of the cost of increased forest fire protection which will be borne by Federal funds.

The average annual benefit resulting from the installation and maintenance of these measures is estimated to be \$36,452,220.

<sup>3</sup> The average annual equivalent value is computed by use of a 2½ percent interest rate for public installation costs and a 4 percent interest rate for private installation costs.



The average annual benefits are as follows:

Reduction in land damage <sup>1</sup> -----	\$321, 720
Increased production on crop, pasture, and forest land-----	35, 660, 000
Reduction in inundation and sediment damage-----	432, 700
Prevention of sediment damage to reservoirs proposed by the Corps of Engineers-----	37, 800
<b>Total-----</b>	<b>36, 452, 220</b>

<sup>1</sup> This does not include reduction in sheet erosion damage to upland soil resources.

The ratio of benefits to costs for land treatment measures is 3.36 to 1.00.

*Costs and benefits from measures for stabilizing small watercourses*

The upstream floodwater retarding structures located in the headwaters of tributary streams are designed to provide temporary storage for runoff. They will reduce both agricultural and nonagricultural inundation damage and furnish protection to flood-plain lands immediately downstream from the site to the extent that they may be put to a more intensive land use.

Improvement of small stream channels by stabilizing the banks, removing obstructions, and installing other protective measures will result in a reduction in stream bank erosion damage, flood plain scour damage, sediment damage, nonagricultural damage to roads and bridges, together with a reduction in damage to proposed Army engineer reservoirs.

The construction of stabilizing and sediment control structures in conjunction with the improvement of subwatershed waterways and the construction of diversions will reduce erosion damage from gullies, reduce the depreciation of watershed lands which accompanies gully erosion in small watersheds, reduce sediment damage, and guarantee the continued effectiveness of the upland treatment measures. Since many upland treatment measures are dependent on these measures, there is a conservation benefit attributable to the program for stabilizing subwatershed waterways. Increased intensity of land use will be possible below many of the proposed diversions.

The design and specifications for these measures are such that they may be maintained at a very low annual cost. However, partial replacement may become necessary from time to time because of conditions over which there is no control. The annual maintenance costs shown in table 5 include an amount to provide for this contingency.

The recommended measures installed on land not under the jurisdiction of the Federal Government are to be operated and maintained by State or local agencies under arrangements acceptable to the Secretary of Agriculture, and installation in any area will not be commenced until such arrangements have been made. The boundaries of any such area shall be determined by the Secretary.

Applying a 2½ percent interest rate for Federal and other public money and a 4 percent interest rate on private expenditures, the equivalent annual cost of installing this stabilizing program is \$2,095,500. The average annual cost of installation and maintenance will be \$4,497,000. The operation and maintenance of \$2,401,500 annually will be borne by non-Federal funds.



It is estimated that the installation and maintenance of measures for stabilizing small watercourses will result in the following average annual benefit:

Reduction in land damage <sup>1</sup> .....	\$2, 079, 180
Reduction in damage due to inundation.....	127, 500
Reduction in sediment damage.....	104, 700
Prevention of sediment damage to reservoirs proposed by the Corps of Engineers.....	12, 300
Conservation benefit.....	3, 648, 000
Increased production on bottom land.....	518, 000
<b>Total.....</b>	<b>6, 489, 680</b>

<sup>1</sup> This does not include any reduction in sheet erosion damage to upland soil resources.

The ratio of benefit to cost for measures for stabilizing small watercourses is 1.44 to 1.00.

### RECOMMENDED ACCELERATED PROGRAM

To carry out the total needed program in the Osage watershed within a 20-year period will require the acceleration of work above the current rates and will require the installation of measures not now included in the current programs of the Department of Agriculture.

In table 5 are set forth the additional items of work and estimated costs that will be required in addition to current programs to carry out the job in 20 years.

TABLE 3.—*Estimated Federal cost of research, social surveys, and land classification, Osage watershed*

<i>Type of research</i>	<i>Cost of recommended programs, total</i>
Conservation and management of farm land:	
Soil and water management.....	\$400, 000
Economic research.....	100, 000
<b>Subtotal.....</b>	<b>500, 000</b>
Forest research:	
Forest watershed management.....	435, 000
Forest management.....	122, 000
Forest grazing management.....	113, 000
Forest fire control.....	126, 000
Forest products.....	116, 000
Forest economics.....	130, 000
<b>Subtotal.....</b>	<b><sup>1</sup> 1, 042, 000</b>
Drainage development:	
Drainage requirements in relation to soil and land use.....	200, 000
Economic research.....	100, 000
<b>Subtotal.....</b>	<b>300, 000</b>
Soil surveys and land classification.....	1, 000, 000
<b>Total.....</b>	<b><sup>2</sup> 2, 842, 000</b>

<sup>1</sup> Includes \$150,000 for costs of installations.

<sup>2</sup> The agricultural experiment stations of Kansas and Missouri expect to provide additional funds for cooperative research in these fields and for cooperative soil surveys.

TABLE 4.—*Total needed program, Osage River watershed*

[Long-term price projection]

Item	Unit	Quantity	Installation cost			
			Federal	Non-Federal, public	Private	Total
Conservation and improvement measures:						
Crop and grasslands:						
Seeding grass and legumes	Acre	1,777,300	\$4,548,300		\$5,687,400	\$10,235,700
Green manure cover crops	do.	341,200	462,500		863,200	1,325,700
Terraces	Mile	150,800	14,680,500		12,056,800	26,737,300
Seeding of pastures	Acre	1,550,100	12,227,800		10,536,200	22,764,000
Pasture clearing	do.	260,000	745,000		4,351,100	5,096,100
Livestock watering facilities	Number	34,300	5,103,500		6,454,900	11,558,400
Lime	Acre	5,396,600	18,114,800		18,878,300	36,993,100
Fertilizer	do.	5,254,800	15,676,600		37,357,200	53,033,800
Outlets and waterways	Mile	15,600	4,657,500		3,810,600	8,468,100
Erosion control structures	Number	28,500	3,688,600		3,020,000	6,708,600
Farm drainage	Mile	2,800	475,900		454,600	930,500
Fence relocation and removal	do.	24,100	251,800		5,223,100	5,474,900
Farm wood lots and shelter belts:						
Planting wildlife areas	Acre	33,000		\$500,900	500,900	1,001,800
Wildlife borders	Mile	3,000		87,900	87,900	175,800
Protection of forest lands from fire	Acre	2,555,700	121,100	121,200		242,300
Tree planting	do.	304,000	3,324,300	678,100	2,178,500	6,180,900
Protection of forest land against grazing	do.	1,620,400	291,500		271,200	562,700
Nurseries	Number	2	129,100	129,100		258,200
Timber-stand improvement	Acre	310,000	961,000		3,844,100	4,805,100
Forest-stream improvement	Mile	230	92,900		92,900	185,800
Forest-land survey and resource inventory	Acre	2,550,000	92,000	23,000		115,000
Research			1,842,000			1,842,000
Soil surveys and land classification			1,000,000			1,000,000
Technical assistance on open land			18,859,900			18,859,900
Technical services on forest land	Acre	2,538,800	2,166,000	2,166,000		4,332,000
Educational assistance			3,752,000	1,848,000		5,600,000
Measures for stabilizing small watercourses:						
Upstream floodwater retarding structures	Number	300	9,495,000		1,055,000	10,550,000
Tributary channel improvement	Mile	200	700,000		300,000	1,000,000
Stabilizing and sediment control structures	Number	28,500	34,200,000		8,550,000	42,750,000
Subwatershed waterway improvement	Mile	12,400	8,928,000		5,952,000	14,880,000
Diversions	do.	3,500	2,219,800		1,816,200	4,036,000
Total			168,807,400	5,554,200	133,342,100	307,703,700

TABLE 5.—*Recommended accelerated program, Osage River watershed*

[Long-term price projection]

Items	Unit	Quantity	Installation cost			
			Federal	Non-Federal public	Private	Total
Conservation and improvement measures:						
Crop and grass lands:						
Seeding grass and legumes	Acre	674,300	\$1,687,300		\$2,157,700	\$3,845,000
Green manure cover crops	do	136,500	185,000		345,300	530,300
Terraces	Mile	87,500	8,549,400		6,893,000	15,447,400
Reseeding pastures	Acre	775,000	6,113,900		5,263,100	11,382,000
Pasture clearing	do	55,000	372,500		338,800	711,300
Lime	do	2,291,300	7,751,200		8,013,800	15,770,000
Fertilizer	do	1,560,000	4,719,500		10,640,300	15,359,800
Outlets and waterways	Mile	9,600	2,871,300		2,349,200	5,220,500
Erosion-control structures	Number	18,300	2,285,100		1,836,500	4,121,600
Fence relocation and removal.	Miles	7,800	156,800		1,761,400	1,918,200
Farm drainage	Acre	2,800	475,900		454,600	930,500
Subtotal			35,167,900		40,063,700	75,236,600
Farm wood lots and shelter belts:						
Forest planting	Acre	168,000	1,302,900	\$325,700	1,628,700	3,257,300
Nurseries	Number	2	129,100	129,100		258,200
Timber-stand improvement	Acre	310,000	961,000		3,844,100	4,805,100
Forest-stream improvement	Mile	230	92,900	92,900		185,800
Planting wildlife areas	Acre	19,800		300,600	300,600	601,200
Wildlife borders	Mile	2,100		61,600	61,600	123,200
Protection of forest from fire	Acre	2,555,700	121,100	121,200		242,300
Tree planting	do	129,900	2,019,800	347,700	449,000	2,816,500
Protection of forest land from grazing.	do	1,620,400	291,500		271,200	562,700
Subtotal			4,918,300	1,378,800	6,555,200	12,852,300
Technical services on open land			13,004,900			13,004,900
Technical services on forest land	Acre	2,430,800	2,078,000	2,078,000		4,156,000
Educational assistance			3,960,000	1,064,900		5,024,900
Research			1,842,000			1,842,000
Soil surveys			1,000,000			1,000,000
Forest land surveys and resource inventory.	Acre	2,550,000	92,000	23,000		115,000
Subtotal			21,976,900	3,165,900		25,142,800
Stabilizing measures for small water-courses:						
Upstream floodwater-retarding structures.	Number	300	9,495,000		1,055,000	10,550,000
Tributary channel improvement.	Mile	200	700,000		300,000	1,000,000
Stabilizing and sediment control structures	Number	28,500	34,200,000		5,550,000	42,750,000
Subwatershed waterway improvement.	Mile	12,400	8,928,000		5,952,000	14,880,000
Diversion	do	3,500	2,219,800		1,816,200	4,036,000
Subtotal			55,542,800		17,673,200	73,216,000
Total			117,605,900	4,544,700	64,297,100	186,447,700

<sup>1</sup> Administration of direct aid amounting to \$1,925,000 is included in the total Federal cost.





SECTION V

**FIVE MILE CREEK WATERSHED (WYOMING)**

**C O N T E N T S**

	Page
Description of watershed.....	197
Economic development.....	201
Current status of work.....	201
Watershed problems.....	202
Total needed program.....	203
Recommended accelerated program.....	213

LIST OF TABLES

Table		
1. Cost of research, soil surveys, and land classification.....		211
2. Total measures needed, recommended program of remaining measures needed.....		213





## SECTION V

### FIVE MILE CREEK WATERSHED (WIND RIVER BASIN, WYO.)

Five Mile Creek watershed, a tributary of the Wind River in Wyoming, is a critical area for which a special agricultural program is being recommended in this report. An attempt to establish an irrigation project within this watershed has created acute financial problems for those attempting to farm and has turned Five Mile Creek into a critical silt contributor to Wind River and the newly constructed Boysen Reservoir.

Five Mile Creek watershed, a small subdivision of the upper Wind River Basin, has been designated by the Wyoming State Mobilization Committee and by local groups and individuals as the most critical area in the State from the standpoint of erosion, seeped land, and silt production and because of the existing condition of this area, a special and accelerated agricultural program is proposed.

The Wind River Basin of 8,000 square miles and approximately 5,000,000 acres includes the drainage area above Boysen Reservoir and while the Five Mile Creek drainage area is currently recognized as the most critical area of this basin, other problem areas do exist, are recognized and should be given special attention and treatment at the earliest possible date.

#### DESCRIPTION OF WATERSHED

##### LOCATION AND SIZE

The Five Mile watershed is located from a point 18 miles northeast of Riverton, Wyo., in Fremont County, and extends upstream westerly and northwesterly from the Wind River Valley for approximately 52 miles. The watershed extends about 12 miles across at its greatest width. The total drainage area is approximately 407 square miles, or 260,480 acres.

##### PRESENT LAND USE, PHYSICAL CHARACTERISTICS

Lands within the watershed are owned as follows:

Department of Interior.....	acres..	<sup>1</sup> 197, 480
Privately owned.....	do....	63, 000

<sup>1</sup> Of this acreage 12,800 acres are to be opened for settlement by 1956.

Topography varies from flat and gently sloping flood plains with terraces and benches to rolling and rough hills. The watershed is bounded on the north by a ridge separating it from Muddy Creek watershed. The benches and broken ridges to the south separate Five Mile from the main Wind River Valley.

The Five Mile subwatershed consists of two use areas: (1) Indian grazing land on the upper 21 miles of the watershed; and, (2) land

under irrigation in the lower 29 miles. Prior to the opening of the Riverton reclamation project, Five Mile was an intermittent stream running only for short periods following heavy thunderstorms or the spring snow melt. The channel had rounded banks and could be crossed at any point. However, since the opening of the irrigation project, water flows continuously from the upper boundary of the irrigated area. This portion of the channel presently varies in width from 300 to 1,200 feet with vertical banks 10 to 35 feet high for a distance of 29 miles and has an average fall of 26 feet per mile. Of the average annual flow, 95 percent of the water is the return flow and wastage from the irrigated farms in the drainage area and the overflow from Ocean Lake located in a depression on the divide between Wind River and Five Mile. The level of Ocean Lake has been raised above its natural level by the return flow and wastage from the project area around Pavillion. The material removed as the Five Mile Channel widens and deepens represents 70 percent of the sediment carried by Wind River. Without adequate corrective measures this process will continue indefinitely and the volume may increase. It is estimated that the mean discharge of Five Mile Creek into Wind River is approximately 100 cubic feet per second and now carries annually 2,000 acre-feet of sediment to be deposited in the Boysen Reservoir just completed.

Of the 63,000 acres of privately owned land, about 48,120 are irrigated. The remaining 14,880 are range land, consisting mostly of small hills and ridges throughout the farm-land area where irrigation is not feasible.

Of the 48,120 acres of irrigated land, there are approximately 30,000 acres of irrigated cropland, 6,500 acres of irrigated pasture, and 6,620 acres of seeped lands. The remaining 5,000 acres are out of production because of heavy concentrations of alkaline salts. An additional 10,000 acres have become seeped and saline and produce very little. With intensive conservation treatment and with good farming methods, about one-half of this 15,000 acres can be brought back into production. The loss of irrigated lands through seepage, high water tables, and low fertility levels, represents a major problem in developing the economy of the area. Basic research in the area is essential to determine the proper solution to the problems.

Crops grown include barley, oats, wheat, alfalfa hay, grass and legume hay, sugar beets, beans, potatoes, and some seed crops such as alfalfa, clover, and wheat grasses.

#### SOILS

Most of the upland soils of Five Mile drainage are residual soils on irregular topography derived from the Wind River formation which is an irregular deposition of sandstones and shales. This irregularity in parent material causes a wide variation of soil textures. The residual upland soils often lack depth, varying from a few inches to a few feet. The upland areas have residual soils that have been reworked by wind and water erosion along ancient water courses and perched valleys. They are usually deep and vary in texture from coarse gravel to clay loams. Many of the soils developed from the saline Wind River shales are raw, saline, and unproductive.

**WASHINGTON**

**HOT SPRINGS**

**THERMOPOLIS**

**BIG HORN**

**SHOSHONE**

**FREMONT**

**SHOSHONE INDIAN RESERVATION**

**SHOSHONE NATIONAL FOREST**

**WASHAKIE**

**CLASSIFICATION OF LAND WITHIN FIVE-MILE WATERSHED**

- INDIAN GRAZING LANDS
- LANDS TO BE IRRIGATED BY 1955
- LANDS POTENTIALLY IRRIGABLE
- LANDS PRESENTLY IRRIGATED

## INDIAN GRAZING LANDS

LANDS TO BE IRRIGATED BY 1955

LANDS POTENTIALLY IRRIGABLE

LANDS PRESENTLY IRRIGATED



The alluvial soils adjacent to, and formed by, Five Mile Creek are deep and heavy textured, highly erosive in character. They are the greatest single source of sediment in the Wind River above the Boysen Dam site.

The arid upland soils are poorly developed, highly calcareous, and have a low content of organic matter. This lack of organic matter causes the soils to be low in available nitrogen and there is insufficient humic acid to render rock phosphates in a usable form to plants. There is little binding material to hold the water for plant use and to prevent erosion by wind and water.

The irregular complex pattern of the land and soils presents many problems under irrigation. Seepage and concentration of salts are common. Subsurface drainage is difficult and, in some cases, may not be economically feasible. There has been severe erosion and loss of lands to crop production because of the very poor permeability owing to solization of soils in the watershed. Conservative use of irrigation water with good management is essential.

#### CLIMATE

The climate of the area is arid. Most of the precipitation falls during the growing season from early April through October. The growing season will average approximately 128 days with the average date for the late and early frosts being May 25 and September 10, respectively. Storm patterns are very erratic, with intensive localized summer storms occurring throughout the area and contributing to soil losses and silt problems.

#### FARM OPERATORS, FARMS, INVESTMENTS, AND INCOME

There are 473 farm families now operating irrigated farms within the watershed and an additional 80 units to be established during the period 1954 to 1956, inclusive. Units average 130 acres in size with an average of 87.7 acres of irrigable cropland per unit. The investment of farmers within the watershed, as of November 1, 1950, was reported to be \$4,982,181 and that of the Bureau of Reclamation \$7,600,000, or a total investment of \$12,582,181, averaging \$26,600 per farm or \$261 for each irrigated acre. The total gross income from the sale of crops for 1950 was \$1,933,627, or approximately \$46 per acre.

In addition to the irrigated farms, there are approximately 150,000 acres of tribal and Indian-owned grazing lands in the watershed and approximately 47,000 acres of public land withdrawn for development by the Bureau of Reclamation not yet opened for entry. The Indian-owned grazing land is controlled by about 20 different operators. This land will continue to be operated as grazing land and measures are included in the proposed program to improve the productivity of the area and to effect runoff dispersion and reduce sediment movement. Reclamation withdrawal lands are in the process of development as irrigated farming units. Measures are included for the land to be let to entry during the next 10 years. Lands in both categories being withdrawn from the public domain represent no capital investment to present occupiers.

## ECONOMIC DEVELOPMENT

Essentially, the area is adapted to livestock farming, such as dairying, small farm flocks of sheep, swine, and poultry. Livestock feeding develops a market for forage and grain, where stock are purchased off the project and fed on farms.

Construction charges for the Bureau of Reclamation irrigation project average \$150 per acre and are being assessed at the rate of \$2 per acre. Operation and maintenance charges are \$2.50 per acre or a total of \$4.50 annually. The construction charges are amortized over 40 years, ranging from the present rate up to \$5 per acre for the last 5 years of the contract.

According to information taken from 40 borrowers for which records are kept, the gross incomes ranged from \$5,129 to \$8,007.56 in 1950. These 40 families had an average gross income in the same year of \$6,350, or a net income of \$2,090. Those with the higher gross income not only received the greatest net income but also had a higher investment principally in livestock with a larger proportion of the farms in irrigated pastures. Indebtedness for real estate is estimated to average \$3,500 per farm and for chattels about \$3,000 per farm or a total of \$6,500. This group has 113 irrigable acres on the average, while the average irrigable acres in the Five Mile area is 87.7 acres. This group too, in most cases, had funds advanced for adequate buildings and fencing and other things lacking on the average farm. After family living expenses and household upkeep have been provided for out of net operating income the operator's ability to finance needed land improvement and water management measures are definitely limited.

Seventy-five percent of the farms in the project are owner-operated.

Market facilities are available through regular trade channels for grain crops and beans. There is a good market for forage crops which are fed to livestock on farms and also used for winter feeding of livestock by range operators.

The usual wholesale markets are Omaha and Denver. Small packing plants at Casper and Riverton slaughter a limited number of livestock. Well-equipped creameries in Riverton and Hudson offer a cash market for cream. A large quantity of milk and cream go to other markets by truck. Sugar beets are delivered to two receiving stations in the area from which they are taken to Worland for processing. Four elevators in Riverton handle many kinds of grain, feed, and seed. One elevator is equipped to roll feed grains and has recently added a pellet-making machine. Local merchants buy wool, seed, and other products. Considerable alfalfa, clover, and grass seeds are purchased by large seed companies.

## CURRENT STATUS OF WORK

## MEASURE OF WORK COMPLETED

Limited progress has been made in establishing conservation practices. Practices which require small capital outlay by the farmer prevail. For example, most progress has been made in crop rotations, green manure, and certain improvements in water distribution. Progress in applying the more difficult and costly practices has been limited by lack of: (1) Farmer financial resource; (2) limited facilities of the

agencies assisting; (3) problems of a scope greater than individual responsibility; and (4) limited information and research with which to deal with certain problems of the area.

The loss of lands within the area from erosion, seepage, and alkali progress so rapidly that the present programs have not been able to cope with the problems. The present programs must be accelerated if the area is to attain its potential productivity and achieve financial success. The recommended program would protect the public investment in the Riverton irrigation project and to some extent Boysen Reservoir and dependent works.

#### CURRENT ANNUAL EXPENDITURES

Approximately \$76,665 annually is being spent by the Department of Agriculture in the watershed in the form of technical, educational assistance and incentive payments. Incentive payments to assist farmers in establishing conservation measures on their lands constitutes almost one-half of this expense.

#### LOCAL COOPERATION

The success or failure of the voluntary and accelerated agricultural program proposed for the Five Mile drainage area is largely dependent on the attitude and understanding of the farmers and ranchers of the area. They have indicated a willingness to cooperate to the extent of their financial resources. The Department of Interior has expressed their interest in the proposed program and has indicated a desire to cooperate. Drainage and irrigation districts operating under State laws and all Federal agencies operating in the area are interested in an early effort to correct the existing critical situation.

#### WATERSHED PROBLEMS

The problems encountered in the development of irrigation farms in the Five Mile watershed are numerous and difficult of solution.

Most of the new irrigation farms were established during the decade 1931-41 by settlers migrating from nonirrigated areas. They were unfamiliar with irrigation and operational practices and with the relationship of water to varying soil types and crop needs. The need for quick cash returns and the lack of adequate capital for facilities and land improvement has intensified the problems of the area. In many instances overirrigation has caused loss of soil, soil fertility, and general deterioration of the area economy.

It is reported that the average use of water on irrigated land in the Five Mile area is  $2\frac{1}{2}$  acre-feet annually. However, this accounts for only 42 percent of the water diverted from the river during the irrigation season. Five thousand acres of land have been abandoned because of salinity and an average of 336 acres annually has been lost to production for the past 10 years. In addition, 10,000 acres have been severely damaged due to waterlogging as a result of transmission and waste loss.

Five Mile Creek is the most serious contributor to the heavy silt load of the Wind-Big Horn River. The construction of Boysen Dam, a short distance below the mouth of Five Mile Creek, has focused



increased attention on this problem. Approximately 70 percent of the total silt load into Boysen Reservoir has come from Five Mile Creek. Waste and return flow from the farms in the irrigation project contribute 95 percent of the water in the Five Mile Channel.

The cost of many of the conservation and erosion control practices needed is prohibitive for individual farmers. Funds available for assistance rendered by the agencies of the Department of Agriculture for land leveling, livestock watering facilities, weed control, silt detention dams, erosion-control structures, and similar practices is not sufficient to secure the necessary coordinated installation of these practices.

The total of requests for assistance exceeds available funds to a degree that approvals are usually for less performance than needed to do the job, or at lower unit rates than permitted by State and National maximums.

The inherent nature of the soils is the cause of such problems as high erodibility, salt and alkaline conditions, and poor natural subsurface drainage.

Noxious weeds are widely distributed throughout the area and unless controlled they will become an erosion and economic threat to the entire project.

There has been insufficient technical, educational, and financial assistance available to these farmers to assure proper irrigation practices. Many of them are veterans and are having their first experience on irrigated farms.

The productive life of much of the seeped land could be prolonged and additional lands prevented from being seeped, or could be brought back into production by correct irrigation and drainage practices.

The public has an interest in finding solutions to these problems and must make the necessary investment if solutions are to be found. The large public investment in the irrigation project and the public funds loaned to individuals are only part of the public values to be protected. Continued decline in the land-resource base of the area would be a serious public loss. Investments that individuals have already made may also be lost.

#### TOTAL NEEDED PROGRAM

The period of time recommended for carrying out this program is 10 years. The number of years required to complete total needs under present rate of progress has not been estimated because the current programs are not keeping abreast with the agricultural problems and, therefore, the conditions are becoming more critical.

It is expected that the Department of the Interior will participate in the program along with the Department of Agriculture and the State college of agriculture.

Those things that appear to be the responsibility of the Department of the Interior and the irrigation district, and which are necessary if the measures proposed herein are to be fully effective are:

1. Canal, lateral, and ditch lining to minimize seepage.
2. Construction of new intercepting drains as required.
3. Keep present drainage systems in good operating condition.
4. Stabilize Five Mile Channel.
5. Keep records on ground water conditions in the area.

6. Improve operation of irrigation systems to prevent unnecessary waste, exclusive of canal and lateral seepage.

7. Regulate the flow in the canal system to the demand for beneficial use, thus reducing the waste flow in Five Mile.

The program being recommended provides for the intensification, acceleration, and adaptation of specified activities currently sponsored by the programs of the Department of Agriculture and State agencies. Certain additional measures, not now included in the regular authorized programs, are being recommended as essential tools in the formulation of a complete and effective accelerated program. The total needed program is set forth in section A of table 2. The accelerated program with estimated costs is set forth in section B of table 2, on the basis of a 10-year installation period.

The program which is being recommended is considered essential to prevent loss to salinity and erosion. The proportion of assistance from the Federal Government and from other public sources has been kept to a minimum consistent with the accomplishment of the objectives and the landowners and operators abilities to finance the remaining costs.

#### RECOMMENDED CHANGES IN LAND USE

Past uses of land under irrigation and recommended changes are as follows:

[Percent]

Period average	Perennial hay and pasture	Legume seed crops	Small grain and corn	Row crops excluding corn	Miscellaneous, including home gardens
1935-39, inclusive.....	25.7	16.6	42.0	10.3	5.4
1940-44, inclusive.....	43.3	8.2	25.8	19.3	3.4
1945-49, inclusive.....	35.6	5.3	29.0	24.8	5.3
RECOMMENDED					
1955-65, inclusive.....	60.0	6.6	18.4	10.0	5.0

Considering the large range area surrounding the Riverton irrigation project and the desirability of a firm feed base to stabilize the range industry, it is believed that the entire economy of the region would be strengthened if irrigated lands, to the extent of effective demand, were used for the production of feeds needed to supplement range forage. Many ranges are in need of hay for supplementary winter feeding to increase the efficiency of range cattle production. A large desert shrub area provides excellent winter range for sheep but the efficiency of range sheep production would be increased if better summer grazing, such as provided by irrigated pasture, were available.

Local markets afford an opportunity for increased production of finished meat animals, beef, lambs, and hogs; as well as sustained production of poultry and dairy products. A sufficient acreage of feed grains should be grown on the project to meet these needs.

In the rotation, approximately 10 percent of the cropland should be in row crops for purposes of weed control. Sugar beet acreage will probably be maintained while the percentage of acreage devoted to dry beans should be reduced.

Soils in the project area are generally deficient in organic matter and nitrogen. Under good farming and irrigation practices, organic material will increase, nitrogen deficiencies will be partially reduced but application of commercial nitrogen will be needed to attain satisfactory yields and quality of certain crops. To improve soil structure and fertility at the fastest possible rate, the maximum acreage of grasses and legumes, consistent with a reasonable level of farm income, should be maintained.

#### CONSERVATION AND IMPROVEMENT MEASURES

##### *Seeding pastures*

The establishment of 13,000 acres of adapted varieties of grasses and legumes is recommended on land to be developed for, and converted to, irrigated pasture. This area is planned for pasture to fit the soil capabilities and to obtain a balanced farming program. Fertilizers will be needed for rapid establishment of vigorous stands, as these lands are presently low in fertility.

##### *Seeding legumes (hay and seed)*

Initial seedings of 19,500 acres of legumes are needed on cropland to establish crop rotations adapted to the capability of cropland, for erosion control, and soil management. These legumes will be used principally for hay to be fed on the farms and for seed production. Legume species to be used will be those able to produce abundant root growth for protection of soil and to produce adequate feed for increased livestock numbers.

##### *Green manure*

The establishment of the regular practice of plowing under green manure crops is needed for maintaining soil structure and tilth and to aid in maintaining soil fertility. The total need of initial establishment of 50,000 acres is planned.

##### *Crop residue management*

The use of straw and stubble residues to give erosion protection on 500 acres of cropland is needed. This measure requires tillage operations which will retain a large part of the crop residue on the surface.

##### *Listing for erosion control*

This is a mechanical operation recommended on 8,000 acres. Listing consists of establishing deep parallel furrows on land not having crop residue or cover crops for controlling wind and water erosion. This practice is recommended following harvest of row crops to provide protection of the soil until spring farming operations begin.

##### *Insect control*

Insect control includes control of lygus, alfalfa weevil, beet leafhoppers, grasshoppers, mormon crickets and others at widely varying costs. Usually two or more treatments are necessary annually. The unit cost of \$35 per acre includes costs of insecticides, labor, and equipment with an average of two treatments per season. Satisfactory income will not be realized from legume hay and seed crops or from sugar-beet production unless these insect pests are controlled.



### *Land leveling*

Leveling of 20,000 acres of land including both irrigated pasture and cropland is recommended. This practice is of great importance to allow proper application and conservation of irrigation water and to minimize erosion.

### *Dry-land pasture management*

Improved methods of management on 165,000 acres of range land is recommended which will consist of proper stocking, protection from burning, and proper seasonal grazing to prevent erosion due to depletion of vegetative cover.

### *Livestock watering facilities*

Available livestock water is the limiting factor to the development of an expanded livestock program in the area. Wells are frequently drilled to depths up to 1,500 feet. Many wells yield no water or the quality of water is very poor. It is therefore necessary to resort to other methods of supplying water for farm and ranch livestock. For that reason the following measures are recommended.

*Reservoirs.*—It is recommended that 150 units be constructed to permit proper distribution of livestock and make available otherwise unusable feed resources.

*Springs and seeps.*—Development of 100 springs and seeps in the foothill area is necessary to insure proper management of pastures and livestock.

*Wells.*—The installation of 135 wells is recommended to provide the necessary supply of water for livestock. Some of these wells will be used for both domestic water supply and for stock water.

*Water storage and pipelines.*—It will be necessary to provide for 100 water storage tanks for livestock, where other methods of supply are not feasible. One hundred thousand linear feet of pipeline will be needed to provide distribution of water for livestock and domestic use.

### *Fences*

Nine hundred miles of fencing will be needed for improving methods of pasture management, establishing new pastures on farms, and for the exclusion of livestock from Five Mile channel to promote revegetation for erosion control. This will be in line with the recommended practice of encouraging farmers to run more livestock and maintain maximum productive use of the pasture land. Also, the immensity of the problem of channel stabilization indicates the necessity of using vegetative rather than structural treatment wherever possible.

### *Application of phosphate fertilizer*

The application of 2,920 tons of  $P_2O_5$  in the form of treble superphosphate and other phosphate fertilizers is needed and recommended. Since the entire area is generally deficient in this fertilizer element, the plan is to make applications on all of the cropland and pasture land twice during the 10-year program period. This fertilizer is needed for establishing vigorous stands of the legumes and for maintaining good production of crops.

### *Application of nitrogen fertilizer*

The soils in this area are inherently low in nitrogen. The practice of applying nitrogen fertilizer to obtain high production of crops and in

establishing stands and maintaining high production of pasture grasses is recognized. The application of 1,550 tons of elemental nitrogen in the form of nitrate and mixed fertilizers is recommended on most of the irrigated land. This practice is needed to supplement the practices of green manure and legume cropping.

#### *Noxious-weed control*

Control of noxious weeds as designated by Woming on some 350 acres of cropland is necessary to check erosion and the serious spread of infestation.

#### *Outlets and waterways*

There is a need for shaping and grading 125 miles of outlets and waterways in preparation for establishing vegetative plantings including grass seeding. These small waterways are needed to provide for the disposition of surplus water at nonerosive velocities into the Five Mile Creek and tributary channels.

#### *Lining farm ditches*

Three hundred miles of permanent ditches should be lined. These are located on the farms near the crest of Five Mile-Wind River divide, where soils are light and ditches are subject to seepage losses. These measures should be installed concurrently with the lining of main canals and laterals.

#### *Irrigation structures*

Construction of 5,750 irrigation structures is necessary for the proper control and application of irrigation water to minimize waterlogging, erosion, and salinity on farms. These structures are imperative to prevent erosion from irrigation and from disposal of waste water on the farm. They will consist of such structures as turn-outs, drops, weirs, chutes, and siphons.

#### *Erosion-control structures*

Installation of 500 erosion-control structures is recommended for the control of natural runoff and to provide for the proper handling of waste water to prevent erosion. They will be of concrete or a combination of concrete headwalls and metal pipe for dropping waste and runoff water into drainage ditches or tributary channels. Overall benefits justify and experience indicates the necessity of the Federal Government bearing most of the costs to secure the needed number and desired quality of installation.

#### *Plantings on water courses*

The planting of 60 miles of tributary channels to erosion-resistant shrubs and grasses is needed. On those presently stabilized, it is believed that plantings will be made under "going programs." As erosion-control structures are installed and headcutting and fingering arrested, additional plantings will be undertaken.

#### *Shelter belts*

The planting of 750 acres of trees and shrubs is recommended for protection against wind and wind erosion. The areas needing protection are farmstead areas including gardens, buildings, feedlots, and corrals and some cropland which is subject to severe wind erosion. The newly planted areas will be protected from grazing.

*Sediment-retarding and water-spreading structures*

The construction of 1,700 sediment-retarding and water-spreading structures and retention dams is recommended, 200 of which will be retardation and retention dams provided with drop outlets designed to desilt the water as it passes through. Fifteen hundred spreader dams will be used to spread runoff water to establish a more vigorous vegetative growth that will protect the spreader area from flood-plain scour and at the same time serve as an area for desilting floodwaters from the higher watershed.

*Diversion ditches*

Seventy-five miles of diversion ditches and dikes are needed. Approximately one-half of these would be complementary to the sediment-retarding and retention structures and spreader and erosion-control structures for the control of floodwater. The remainder would be on farms to control and manage excess water used in irrigation.

*Drainage*

No drainage works are included in the recommended program, although some serious drainage problems are recognized. The lining of canals and laterals will materially reduce the need for drainage. Reducing the amount of irrigation water applied to that required for optimum growth of crops would further reduce the necessity for drainage. Drainage ditches as are required to intercept and dispose of water lost from seepage in the canal system should be installed as an integral part of the Bureau of Reclamation construction program. In addition, some farm drainage will be necessary. Because of peculiar soil structure it is believed that exhaustive drainage research should be carried on in the watershed before extensive farm drainage is initiated. As research and farm experience develop better techniques, they will be applied on a broader scale. It may be necessary at a later date to assist in the installation of farm drainage systems if the methods used are too costly to be borne by the farmer from his own resources.

## CREDIT NEEDS

Three-fourths of the present settlers in the Five Mile drainage area are in need of additional land development, farm enlargement, or additional livestock, farm machinery, or funds for other operating expenses. Over half of the settlers are unable to make these needed expenditures from their own resources and will require adequate credit to meet these needs as well as to carry their part of the cost of the needed conservation and improvement measures.

Up to June 30, 1951, production and water facilities loans amounting to \$2,339,000 had been made in this area to individual farmers by the Farmers Home Administration. Approximately \$300,000 per year in production and water facilities loans for the next few years are in prospect.

Sixty loans for farm development, enlargement, or acquisition have been made in the Five-Mile drainage area since 1940 and 30 more are estimated for the next 10 years under present agricultural program conditions. Eleven of the loans made since 1940 have been repaid in full.

Under an accelerated agricultural program to stabilize the agricultural economy in the area, loan funds will be needed for loans as those authorized to be made by the Farmers Home Administration.



Supervision and guidance will be provided with each loan to assure establishing farm practices and carrying out farm development work necessary to bring their lands into full production.

With the checking of the rate of land deterioration and renovation of land already damaged, it is estimated that 195 supervised loans totaling \$1,168,000 will be needed for farm development and farm acquisition. Operating loans during the 10-year period are estimated at \$3,125,000. Water-facilities loans, including advances for new domestic and stockwater development, leveling, irrigation structures, and rehabilitation of existing wells, are expected to total \$310,000. Administrative costs to make these loans and supervise them is estimated at \$244,000 over the 10-year period. This will be in excess of \$100,000 available under the current program.

#### EDUCATIONAL ASSISTANCE

The success of the program will depend upon the knowledge and awareness of the people of the problems and their ability to cope with such problems of their individual units. Additional funds are needed to develop an accelerated educational program to bring about improved water use, increased soil fertility, improved drainage practices, and crop rotations that will facilitate the development of the above practices. This educational need will be expanded in 1954 by the addition of 80 new farming units, and increase the need of small group assistance, individual contact and instruction, and demonstrations that will aid new settlers in establishing approved crop, livestock, and water-management practices.

There are approximately 1,400 farms and ranches in Fremont County. One-third of these units are located in the Five-Mile watershed. Present Extension personnel consists of a county agent, assistant county agent, and a home demonstration agent. Approximately one-third of their time is devoted to the Five-Mile area. In addition to these three workers, there is also an assistant county agent employed under a working agreement with the Bureau of Reclamation who spends approximately 100 percent of his time in the area. This contract expires in 1952.

The accelerated program will require additional publications and the development by subject-matter specialists of programs related directly to the area. The development of these programs and publications for use of the people in the area would require additional money for travel and publications. A total of \$153,000 will be required for extension education over the 10-year period. This would require \$70,000 in excess of funds that will be spent under the current rate of extension funds now used in the area.

#### TECHNICAL ASSISTANCE

There is a need for accelerating the preparation and application of conservation farm plans. This involves making soil-capability maps, lay-outs, and plans for application of land and water-conservation practices. Technical services, together with conservation payments for approved practices, are necessary for effective application of the program. Technical services needed for this job during the 10-year period amount to \$437,400. This is \$272,400 in addition to expenditures for this purpose that will be made under the current program rate.

## ADMINISTRATION OF DIRECT AIDS

The amounts shown as direct aids for the installation of land-treatment measures are the best estimates possible at this time. These rates may vary up or down from time to time to reflect current installation costs. They should not be construed as fixed rates for the entire period of installation.

The Federal cost in relation to total costs in this report may vary somewhat from the relationships in House Document 373 in that costs of most measures in this report reflect only the immediate out-of-pocket outlay. For example, the unit cost of \$7 per acre for seeding pastures and for seeding legumes for hay and seed reflect the average cost for seed of adapted varieties at a representative seeding rate. Indirect costs for land preparation, irrigation, and loss of income from the land while the stand is becoming established, are not considered. House Document 373 reflects unit costs of \$12.90 per acre for similar measures.

Practices which accrue benefits to the farmer, such as the green-manure practice, will be accomplished within the present payment rate.

An increase in administrative costs is involved in making on-the-farm contacts necessary to expand the conservation program.

## RESEARCH AND SOIL SURVEYS

The need for research in the Five Mile Creek watershed arises mainly because of the need to arrest the declining productivity of soils on the Riverton reclamation project and the need to avoid such productivity losses in land to be brought into cultivation under extension of this project. Economical means of managing soil, water, and crops to insure permanently productive agriculture must be sought. The research proposed will be used to meet problems of the Riverton project, its extension and other areas having similar conditions. Its justification is not limited to guiding the application of measures proposed in this report for Five Mile Creek.

Cost estimates cover estimated Federal expenditures only. The State is expected to contribute as it is able. The estimates are for the first 10 years. At the end of that time a reexamination of research needs will be made.

Soil surveys are the means by which we fit particular uses and practices to the soils to which they are suited. Soil surveys are necessary in making the soil-capability maps required for applying conservation practices.

*Water, soil, and plant relationships in crop production on irrigated land*

This watershed includes a portion of the Riverton reclamation project and the greater part of an extension of this project known as the Fremont unit, where a large additional acreage is proposed for irrigation.

In the Five Mile area in the Riverton project, considerable acreage has already become nonproductive as a result of salinity and water-logging due to excessive applications of irrigation water and seepage from canals. Irrigation tail waters have caused great erosion of the channel and flood plain of Five Mile Creek, with consequent deposition of sediment in channels below.

Similar problems will afflict the new acreage unless research can discover ways to overcome them. Research must deal with both water management and soil management. It must discover how much water is needed for the diverse soils and crops, and how to apply it so as to avoid further loss of productivity by waterlogging, salinization, and erosion. It must discover how best to drain the different soils and how to reclaim saline areas; and what crops, cropping systems and fertility practices are needed to insure high production.

The research would be undertaken cooperatively between the Department of Agriculture and the Wyoming Agricultural Experiment Station on land provided by the Bureau of Reclamation within the development farm, on farmers' fields, and in the laboratory and greenhouse. The results will have application to other irrigation areas in the Wind River Basin and other areas having similar problems.

### *Economic problems*

Certain types of economic research are needed to supplement the water, soil, and plant research of the area. Economic evaluation of various cropping, irrigation, and soil management practices is desirable. The major shift that is proposed from cash crops to legumes and grasses will involve many problems.

Sizes and types of farms likely to succeed under the peculiar irrigation arrangements in this area need to be determined. To determine these factors such as the repayment of the farmer's share of development and operating costs, and equipment and labor efficiency must be considered.

Irrigation farming requires large amounts of capital for the individual farmer. Large outlays are needed for leveling and adapting the farm for irrigation, constructing buildings, and purchasing equipment and livestock. It is highly important that studies be made to determine the extent of capital requirements, and to determine what modifications of credit facilities, if any, may be needed to assure adequate credit service.

### *Soil surveys and land classification*

Detailed soil surveys are needed on land now irrigated and of lands to be brought under irrigation to support the programs of irrigation, drainage, salt reduction, and erosion control. In addition a reconnaissance soil survey is proposed for all grazing lands in the watershed.

TABLE 1.—*Estimated Federal cost of research, soil surveys, and land classification, Five Mile watershed, Wyoming*

<i>Type of research</i>	<i>Cost of recommended programs</i>
Irrigation development:	
Water, soil and plant relationship.....	<sup>1</sup> \$437, 000
Economic problems.....	<sup>2</sup> 30, 000
Total.....	467, 000
Type of soil surveys:	
Type 1.....	<sup>2</sup> 41, 000
Type 6.....	<sup>2</sup> 8, 000
Total.....	<sup>3</sup> 49, 000

<sup>1</sup> Includes \$20,000 installation and equipment.

<sup>2</sup> Study terminates at end of 6 years.

<sup>3</sup> The Wyoming Agricultural Experiment Station expects to provide an additional \$105,000 for cooperative research on irrigation development.



## BENEFITS

The benefits to be derived from the proposed works of improvement are of three kinds: (1) The preservation and improvement of the basic productivity of farm lands where the benefits accrue directly to farm families; (2) runoff retardation and sediment abatement where the benefits accrue to the public generally; and (3) the stabilization of the economy of central Wyoming by providing complementary feed resources needed in the range livestock industry and by insuring a permanent type of agriculture upon which is based the development of towns and cities and upon which the prosperity of commerce, industry and the public utilities largely depend.

Under item (1) above with the installation of adequate facilities for conveyance and proper application of water to the land; with the establishment of improved crop rotations including permanent irrigated pastures; the application of fertilizer materials needed to establish soil building crops in the rotation and to insure economic yields; the development of needed domestic and livestock water; reduction of acreage lost to seepage by 200 acres annually and with the adoption of known improvements in farming and irrigation practices, the over-all value of production may be increased by 25 to 40 percent annually, or approximately \$15 per acre of irrigated cropland.

Over the past 10 years the acreage abandoned because of seepage and salinity has amounted to 3,360 acres or an average of 336 acres annually. Due to soil stratification and irregular subsurface formation, some additional acreage will probably be lost to seepage but the installation of the proposed program will reduce this by at least 200 acres annually and will materially improve the productivity of a considerable acreage of border-line land now threatened by excess salinity.

Under item (2) above direct benefit will be derived by the reduction of the siltation rate in the project's distribution and drainage system. In the design of Boysen Dam, because of the heavy silt burden of the river, it was necessary to provide a considerable portion of the total capacity for sediment retention. The cost of the project to the Federal Government was \$33,439,000. The timely installation of the recommended works of improvement on the Five Mile watershed will extend the effective life of Boysen Reservoir but no attempt is made to place a monetary valuation on the benefit.

The benefits under item (3) are indirect and no attempt is made to evaluate them, nevertheless they are large and of themselves justify an investment on the part of the public that they may be realized.

*Economic justification*

The measures and works of improvement for the accelerated portion of the recommended program shown in section B of table 2 will result in the following measurable average annual benefits:

Increased production of field crops and pasture-----	\$799, 500
Value of the investment in improvements, etc., appurtenant to land saved from seepage and salinity-----	52, 200
Total annual benefits-----	1 851, 700

<sup>1</sup> Benefits are calculated on the basis of prices estimated by the Bureau of Reclamation for the Riverton project.

Annual costs of the program are computed as 2.5 percent of the total Federal costs of the accelerated portion of the program, 4 percent of the costs to other public and private interests, and in addition the

necessary maintenance costs to local interests of \$345,430, making a total of \$504,475.

### RECOMMENDED ACCELERATED PROGRAM

To carry out the total needed program in the Five Mile watershed within a 10-year period will require the acceleration of work above the present rates of installation and will include some measures not included in current programs of the Department of Agriculture.

The effectiveness of the measures recommended are dependent upon the concurrent installation of interrelated measures including those for which the Department of Interior has the initial responsibility.

The difference in quantities and values shown in section A of table 2 for the total needed program and those in section B for the recommended program represent the estimated accomplishments of current programs during the 10-year period.

TABLE 2.—Total needed program and recommended accelerated program—Five Mile watershed <sup>1</sup>

Measures	Units	Section A—Total measures needed		Section B—Recommended accelerated program—Installation costs			
		Quantity	Estimated cost	Quantity	Federal	Private	Total
For cropland only:							
Seeding pastures.....	Acres.....	13,000	\$91,000	7,150	\$32,000	\$18,000	\$50,000
Seeding legumes for hay and seed.....	do.....	19,500	136,500	17,550	28,800	94,200	123,000
Green manure.....	do.....	50,000	150,000	-----	-----	-----	-----
Crop residue management.....	do.....	500	500	500	-----	500	500
Listing for erosion control.....	do.....	8,000	4,000	5,750	750	2,125	2,875
Insect control.....	do.....	17,000	595,000	12,300	-----	430,500	430,500
Land leveling.....	do.....	20,000	500,000	18,000	225,000	225,000	450,000
Cropland and pasture:							
Dry pasture management.....	do.....	165,200	16,520	-----	-----	-----	-----
Livestock water facilities:							
Reservoirs.....	Number.....	150	30,000	90	9,000	9,000	18,000
Springs and seeps.....	do.....	100	2,500	-----	-----	-----	-----
Wells, stock and domestic.....	do.....	135	202,500	95	47,025	95,475	142,500
Water storage.....	do.....	100	7,500	100	-----	7,500	7,500
Pipelines.....	Lineal feet.....	100,000	50,000	100,000	-----	50,000	50,000
Fences.....	Miles.....	900	585,000	524	140,000	200,000	340,000
Fertilizer materials:							
Nitrogen.....	Tons.....	1,550	558,000	1,418	210,480	300,000	510,480
Phosphate (P <sub>2</sub> O <sub>5</sub> ).....	do.....	2,920	584,000	2,600	182,000	338,000	520,000
Noxious weed control.....	Acres.....	350	21,000	220	2,000	4,200	13,200
Outlets and waterways.....	Miles.....	125	66,000	114	36,000	24,000	60,000
Lining farm ditches.....	do.....	300	528,000	270	237,600	237,600	475,200
Irrigation structures.....	Number.....	5,750	345,000	4,000	120,000	120,000	240,000
Erosion control structures.....	do.....	500	300,000	475	171,000	114,000	285,000
Plantings on watercourses.....	Miles.....	60	6,000	-----	-----	-----	-----
Shelterbelts.....	Acres.....	750	30,000	335	2,512	10,887	13,339
Sediment control.....	Number.....	1,700	225,000	1,250	93,750	93,750	187,500
Division ditches and dikes.....	Miles.....	75	18,750	75	10,310	8,440	18,750
Subtotal.....	-----	-----	5,052,770	-----	1,548,227	2,383,177	3,938,404
Supporting measures:							
Credit.....	-----	-----	244,000	-----	100,000	-----	100,000
Educational assistance.....	-----	-----	152,850	-----	69,800	-----	69,800
Technical assistance.....	-----	-----	437,400	-----	272,400	-----	272,400
Administration of direct aids.....	-----	-----	90,840	-----	35,350	-----	35,350
Research.....	-----	-----	467,000	-----	467,000	-----	467,000
Soil surveys:							
Type 1.....	Acres.....	63,000	41,000	63,000	41,000	-----	41,000
Type 6.....	do.....	197,480	8,000	197,480	8,000	-----	8,000
Subtotal.....	-----	-----	1,441,090	-----	993,550	2,383,177	993,550
Total.....	-----	-----	6,493,860	-----	2,541,777	2,383,177	4,931,954

<sup>1</sup> Costs are Production and Marketing Administration estimates based on 1951 prices for Wyoming.

<sup>2</sup> Includes \$7,000 of State aid not listed except in the total item of the table.





## SECTION VI

### SOIL SURVEYS, LAND CLASSIFICATION AND RESEARCH FOR IRRIGATION DEVELOPMENT

#### PURPOSE

It is the purpose of this section of the supplemental report to House Document 373 to recommend a program of irrigation development research and an integrated program of soil surveys within a 10-year period on 7,285,000 acres of land lying within areas in the Missouri Basin now under investigation for potential irrigation projects or for established irrigation projects needing rehabilitation or improvement.

#### SOIL SURVEYS AND LAND CLASSIFICATION

The surveys will be made in close cooperation with the State agencies having responsibility for soil surveys and with the Department of the Interior agencies responsible for classification of land for irrigation.

Some soils in the basin are well suited to irrigation, and some are not; hence, adequate soil information is imperative to select lands to be irrigated so that limited water supply will be used to best advantage. Failure to do so may result not only in waste of public funds, but also in waste of the lives and energies of people if they build their homes and irrigation farms on land unsuited for irrigation.

Soil information is needed not only to select land for irrigation, but also to determine the kind of crops to be grown under irrigation, the kind of tillage practices, the character of fertility measures, the need for and method of drainage, the method of salt removal, and the method of irrigation. Soil surveys will be designed to indicate the suitability of the soils for irrigation and to provide information useful to farmers in choosing crops and production practices that fit the soil once irrigation is provided. Difficulties in maintaining productiveness of some soils in areas now irrigated have arisen because of failure to classify soils correctly. There is need for adequate soil inventories in existing irrigation districts to guide rehabilitation and betterment efforts.

*Present rate of soil surveys.*—Soil surveys now being made in areas under investigation for potential irrigation are covering only approximately 384,000 acres a year. The mapping is being done in Montana, North Dakota, South Dakota, Kansas, Nebraska, and Wyoming. This rate is not adequate to provide the essential soil inventory needed for irrigation classification.

*Total need for irrigation surveys.*—It is estimated that approximately 12 million acres will eventually require surveys in sufficient detail for irrigation classification. The recommendation is made here to complete surveys within the next 10 years on only that portion of this

area under consideration for development in irrigation projects or now in irrigation projects needing rehabilitation.

The major project areas now under investigation by the Bureau of Reclamation include the Missouri-Souris project area and alternate areas in Montana and North Dakota; the Oahe and James River project areas in South Dakota; the lower Platte River area in Nebraska; the Narrows project in Colorado; the Kendrick and River-ton projects in Wyoming; the Webster, Kanopolis, and Scandia units of Kansas.

*Recommended program.*—It is recommended that project authorization be given to carry out over a 10-year period soil mapping and classification of 7,285,000 acres in sufficient detail to provide the basis for irrigation classification, for making farm plans, and for allied purposes. This is 3,445,000 acres more than can be done within this time period under current rates of available funds.

Areas to be covered will include lands in proposed irrigation projects and lands already under irrigation but in need of soils information to provide a basis for irrigation rehabilitation or improvement. Acreages by States are set forth in table 1. The area to be surveyed does not include areas in the upper South Platte watershed of Colorado; Five Mile Creek watershed of Wyoming; the Osage watershed of Kansas and Nebraska; the Blue River watershed of Nebraska and Kansas; or the Salt-Wahoo Creeks watershed of Nebraska.

The total cost of surveying and publication of maps for the 7,285,000 acres is estimated at \$4,736,000. This will require \$2,240,000 in addition to current rate of expenditure over the 10-year period.

TABLE 1.—*Estimated acreage and costs of soil surveys in support of irrigation*

State	Acres	Cost <sup>1</sup>		
		Federal	State <sup>2</sup>	Total
Colorado.....	46,000	\$30,000	0	\$30,000
Kansas.....	300,000	145,000	\$50,000	195,000
Montana.....	1,187,000	682,000	90,000	772,000
Nebraska.....	3,103,000	2,017,000	0	2,017,000
North Dakota.....	1,225,000	596,000	200,000	796,000
South Dakota.....	981,000	288,000	350,000	638,000
Wyoming.....	443,000	288,000	0	288,000
Total.....	7,285,000	4,046,000	690,000	4,736,000

<sup>1</sup> Costs figures at 65 cents per acre, including publication. Continuation of current rate of expenditure will provide for \$2,496,000 of this amount over the 10-year period. An additional sum of \$2,240,000 will be required to complete the mapping in 10 years.

<sup>2</sup> State portions of the total cost are based on present State funds available for soil surveys.

#### IRRIGATION DEVELOPMENT RESEARCH

Irrigation research will be conducted in areas now irrigated to supplement work already being done and will be expanded to include problems of extending irrigation into potentially irrigable areas. This program will include factors affecting water, soil, and plant relationships in crop production in the Missouri Basin. Heavy investments of public funds in developing new irrigation as well as high investments by individual irrigators make it imperative to get this phase of research under way promptly. This research will be planned and carried out cooperatively by the Department of Agricul-

ture and the State agricultural experiment stations and in consultation with the Bureau of Reclamation.

*Recommended program.*—It is recommended that project authorization be given to carry out over a 10-year period adequate irrigation development research to keep abreast of needs imposed by irrigation with particular emphasis on potentially irrigable and newly developed irrigated land. Present facilities and funds are not adequate to serve this function. Allocation of funds will be determined by the areas where development is contemplated or under way. The estimated total cost is \$5,945,000 Federal funds and \$2,589,000 State funds as set forth in table 2.

TABLE 2.—*Estimated funds for irrigation development research (10-year period)*

Type of research	Federal funds	State funds <sup>1</sup>	Total
Water, soil, and plant relationships .....	\$3, 470, 000	\$880, 000	\$4, 350, 000
Economic problems of irrigation .....	2, 475, 000	1, 709, 000	4, 184, 000
Total .....	5, 945, 000	2, 589, 000	8, 534, 000

<sup>1</sup> Participating in this cooperative research will be the agricultural experiment stations of all the Missouri River Basin States.







